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EVALUATION OF CARCASS TRAITS OF HEREFORD STEERS THROUGH ULTRASOUND IN DIFFERENT NATIVE PASTURE: PARTIAL RESULTS

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Abstract –Beef quality traits can be influenced by different finishing diets which can be assessed in the carcass of the live animal through ultrasound technique. The aim of this study was assess the influence of different pastures in the carcass traits of Hereford steers. Were evaluated the carcasses of 36 steers divided into 3 different sorts of pasture: native pasture (T1), fertilized native pasture (T2) and improved fertilized native pasture (T3). The carcass traits assessed were live weight (W, kg), rib eye area (REA, cm^2), backfat thickness (BF, mm) and rump fat thickness (RF, mm). There was highly pasture* time of year effect for all pasture sorts and in all carcass traits. The live weight of the steers were also significantly different among the treatments, 269.66, 306.06 and 333.91 kg respectively T1, T2 and T3 (P<0,0001). There was no significant differences for carcass characteristics between T1 and T2 (P>0.05) for REA (35.33, 37.31 cm^2), BF (1.06,1.23 mm) and RF (0.82, 1.11 mm) , respectively. T3 carcass traits were significantly divergent from T1 and T2 for REA (41.33 cm^2), BF (1.87 mm) and RF (1.61 mm). Improved fertilized native pasture demonstrated be the best alternative for animal finishing diets resulting in better carcass traits.

I. INTRODUCTION

The production of high quality products has been a major focus of the beef cattle industry. The carcass quality traits prediction is a great concern in animal production once it can be applied to target the beef products to specific markets. Thus the carcass characteristics assessment through ultrasound is a useful and objective tool to estimate the fancy beef traits as back fat thickness, rib eye area and rump fat thickness. According to the different sort of pasture offering for animal feed, there will be roughly distinct beef quality outputs. The aim of this study was evaluate the influence of native pasture, fertilized native pasture and improved fertilized native pasture in the live weight, rib eye area, back fat thickness and rump fat thickness carcass traits of Hereford steers. These results will be useful for the decision take of the producers in which pasture utilize to finish steers in grasslands.

II. MATERIALS AND METHODS

Were evaluated the carcasses of 36 live steers of Hereford breed from winter of 2012 till summer of 2014, totalizing 6 measurements which are our partial data set. The steers are kept into 3 different sorts of pasture: native pasture (T1), fertilized native pasture (T2) and improved fertilized native pasture (T3). The carcass traits assessed were rib eye area (REA, cm2), back fat thickness (BF, mm) and rump fat thickness (RF, mm). The carcass characteristics evaluation were carried out by ultrasound evaluation using ALOKA 500V equipment with linear probe of 17.2cm, 3.5 MHz together with a standoff and a system for image capture. REA and BF images were taken with the probe positioned transversally to *Longissimus* muscle between 12th and 13th rib. The RF image was taken with the probe positioned in the intersection between *Gluteus medius* and *Biceps femoris* muscles, localized between ilium and ischium bones. In the same day of the ultrasound evaluation the steers were weighted (W, kg). The analysis model included the random effect of paddock nested in treatment and the fixed effects of treatment, time of year and their interaction. Tukey tests means were applied for comparison among the treatments and carcass traits mean [1].

III. RESULTS AND DISCUSSION

Mean values analyses data are grouped in Table 1. The live weight of the steers were significantly different among the treatments, 269.66, 306.06

and 333.91kg respectively T1, T2 and T3 ($P<0.0001$). There was no significant differences for carcass characteristics between T1 and T2 ($P>0.05$) for REA (35.33, 37.31cm^2), BF (1.06, 1.23mm) and RF (0.82, 1.11mm), respectively. The T3 carcass traits were significantly divergent from T1 and T2 for REA (41.33 cm^2), BF (1.87 mm) and RF (1.61 mm). There was highly pasture*time of year effect for all pasture sorts and for all carcass traits.

Devicenzi *et al.* [2] finished Angus steers in three pastures, and found similar behavior of this study in live weight of finished animals. Steers fed natural pasture (514.8 kg) and improved-natural pasture (496.9 kg) were statically similar, in the other hand, the steers fed annual-summer grassland were distinct from the others (458.1 kg) ($P< 0.0023$). Conversely the same authors did not found significant differences for REA, BF and RF among the grass fed animals as showed in the present research.

Table 1 – Means for carcass traits related to the different pastures

Total means	Native Pasture	Fertilized Native Pasture	Improved-Fertilized Native Pasture	Pasture*time of year effect
W (kg)	269.66^a	306.06^b	333.91^c	<0.0001
REA (cm^2)	35.33^a	37.31^a	41.33^b	<0.0001
BF (mm)	1.06^a	1.23^a	1.87^b	0.0001
RF (mm)	0.82^a	1.11^a	1.62^b	0.0012

W – weight; REA – Rib Eye Area; BF – Backfat thickness; RF – Rump fat thickness.

^{a} same letters in the same line show no significant difference

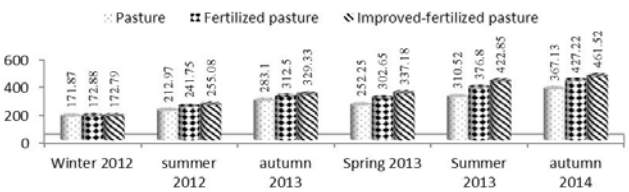

Fig 1 – Live weight of the steers for the pastures during the time of the year

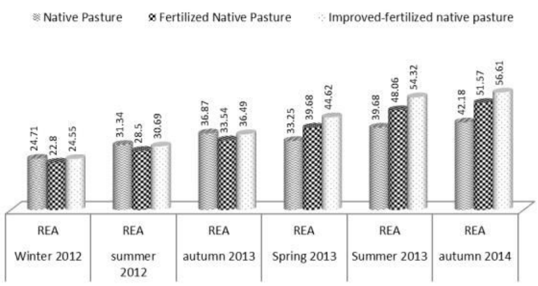

Fig 2- Rib eye area (REA) for the pastures during the time of the year

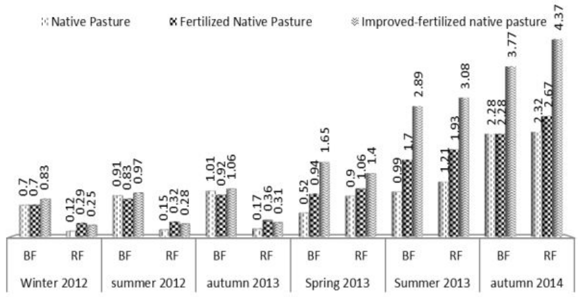

Fig 3- Backfat thickness (BF) and rump fat thickness (RF) for the pastures during the time of the year

IV. CONCLUSION

During the evaluated period of time, steers fed improved-fertilized native pasture demonstrated to have carcasses with superior quality traits. Thus this sort of grassland can be an interesting alternative for finishing beef cattle efficiently.

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EXPRESSION OF THYROID HORMONE-RESPONSIVE PROTEIN (THRSP) IS RELATED TO INTRAMUSCULAR FAT IN A F_2-CROSS BETWEEN CHAROLAIS AND HOLSTEIN

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Abstract – Intramuscular fat (IMF) is a major determinant of beef quality but the underlying genetic mechanisms for its accumulation in skeletal muscle are only partially understood. The study aimed at identification of candidate genes for IMF deposition in cattle. Global gene expression was analyzed in *M. longissimus* of 2 x 10 bulls of a Charolais x Holstein F_2 population differing largely in IMF content. Among the differently expressed genes 4 were verified by quantitative PCR and revealed significant correlations to IMF and further marbling traits. Most of the candidate genes are known to be expressed predominantly in adipocytes. This made it likely that the observed differential expression resulted from higher IMF content of the muscle. In contrast, thyroid hormone-responsive protein (THRSP) is expressed in muscle as well as in fat cells. Thus, the observed 6-fold increase of expression in highly marbled animals may result from genuine expression differences and makes it a promising candidate for further investigations.

I. INTRODUCTION

Identification of genes influencing intramuscular fat (IMF) deposition in cattle is of interest since IMF is a major determinant of beef palatability and tenderness (1). To this end, several studies compared global gene expression profiles between (2, 3) or within (4) breeds and crosses with divergent marbling traits. Comparisons between breeds are more likely to identify a larger number of differentially expressed genes. However, expression differences related to the target traits must be dissected from those which are specific for a breed but not related to the trait of interest (5). On the other hand, phenotypic differences in IMF are often small within a breed thus exacerbating the identification of differently expressed genes. In contrast, our study employed bulls from a F_2-population derived from a Charolais x Holstein cross. The F_2 offspring is characterized by a high variability in IMF content and a well-defined genetic background.

The aim of this study was to identify candidate genes for IMF content in *M. longissimus* by comparative expression profiling. Furthermore, the relationships between expression of candidate genes and histological traits of *M. longissimus* and of the embedded IMF cells were elucidated.

II. MATERIALS AND METHODS

Animals and phenotypes

Each 10 bulls with either high or low IMF ("High", "Low") were selected from a F_2 population derived from Charolais and Holstein (6). Group selection considered equal appearance of sires in both groups. Bulls were kept under standardized conditions and slaughtered at an age of 18 months. Details of sampling and phenotyping were described elsewhere (7).

Analysis of gene expression

Total RNA was isolated from *M. longissimus* of the bulls at slaughter. Gene expression patterns were assessed using the GeneChip® Bovine Genome Array (Affymetrix, Santa Clara, USA). Between groups comparisons for single genes were done with Fisher's LSD test. Regulated pathways were identified with Ingenuity Pathway Analyses (IPA) software (Ingenuity Systems, Redwood City, USA).
Expression differences for selected genes were verified with RT-qPCR (iCycler MyiQ 2, BioRad, Munich, Germany) in duplicates (Table 1). The qPCR protocol included an initial denaturation step (95 °C for 3 min) followed by 45 cycles (95 °C for 10 s, 60 °C for 30 s, 70 °C for 45 s) and a final melting curve analysis. Crossing point values were determined automatically by iQ5 Software (Bio-Rad). The amplification efficiency E was calculated from a standard curve derived from six serial dilutions.

Table 1: Primers for RT-qPCR

Gene symbol	Primer (forward/reverse, 5'-3')
THRSP	GAGATGGAAGAGGCTGAGGA
	CAGGGTAAGATGGGTGAGGA
CIDEC	CCGTATTCATGGTCCTCCAC
	TGCCATAGAGAGTTGCCTTC
INSIG1	AGTCACCTTGGAGAGCCACA
	ACGGTCAAATGTCCACCAGA
ACLY	CAAGAAGGCAGACCAGAAGG
	CTGGGCGGTACAGCTTAGAG
ZFP423	GAGGAGAGGAATGAGGACGA
	TCCTTACTGGAGGGAGACGA
FNDC5	GGTAAGCTGGGATGTCTTGG
	CTGACCCTGGATGGATATGG
TOP2B	AAGAAAACAGCACCGAAAGG
	GAGGTCTGAGGGGAAGAGGT
B2M	CAGCTGCTGCAAGGATGG
	ATTTCAATCTGGGGTGGATG

Expression values were normalized to beta-2-microglobulin (B2M) and topoisomerase II beta (TOP2B). Expression differences between the two cattle groups (High vs. Low IMF) were analyzed using the REST algorithm (REST 2009, Qiagen, Hilden, Germany).

Statistical analyses
Phenotypic traits were analyzed with ANOVA (Statistica, StatSoft, Hamburg, Germany) considering group and sire as fixed effects. Between-breed comparisons for single genes on the microarray were done with Fisher's LSD test.

III. RESULTS AND DISCUSSION

Phenotypes
As expected, both groups of bulls selected for divergent IMF content in *M. longissimus* differed significantly in fatness traits despite comparable carcass weights. All fat depots were larger in the "High" group.
Meat quality traits were not significantly different between the groups (Table 2).

Table 2: Carcass and meat quality traits (LSM ± S.E.)

Trait	Low IMF	High IMF
Cold carcass weight (kg)	408.1 ± 8.1	389.7 ± 8.1
Visceral fat (kg)	34.2 ± 2.4^A	56.7 ± 2.4^B
Fat (% of CCW)	12.8 ± 1.0^A	21.7 ± 1.0^B
Protein (% of CCW)	15.1 ± 0.2^a	13.3 ± 0.2^b
LM area (cm²)	106.6 ± 4.0^a	92.5 ± 4.0^b
IMF content (LM; %)	1.9 ± 0.6^A	7.0 ± 0.6^B
pH (LM, 24 h p. m.)	5.51 ± 0.07	5.44 ± 0.07
Shear force (LM, 14 d p. m., kp)	11.6 ± 0.2	10.3 ± 0.2

a, b: p<0.05; A, B: p<0.001; CCW: cold carcass weight; LM: *Musculus longissimus*

Tenderness of *M. longissimus* was slightly but not significantly improved in "High IMF".
Muscle structure was not different between the groups, whereas marbling traits and fat cell size differed significantly (Table 3). The mean area of muscle fibers was not different between the groups. In contrast, bulls with high IMF content were characterized by a higher mean fat cell diameter which accounts at least in part for the larger fat area percentage in *M. longissimus*. The fat cells in the "High" group were connected to larger marbling spots as measured by the parameter "largest fat area in LM".

Table 3: Muscle fiber and marbling traits in *M. longissimus* (LSM ± S.E.)

Trait	Low IMF	High IMF
Fiber area (µm²/fiber)	2722 ± 166	3085 ± 157
Fiber number (n/cm²)	37553 ± 1891	33292 ± 1794
Fat area (%)	3.1 ± 0.8^A	9.6 ± 0.8^B
Largest area (mm²)	99 ± 42^a	243 ± 42^b
Cell diameter (µm)	81.8 ± 4.0^A	100.6 ± 4.0^B

a, b: p<0.05; A, B: p<0.001

Analysis of gene expression in M. longissimus
Analysis of microarray expression data in both groups revealed a total of 178 differentially expressed genes (DEGs; $p < 0.05$) out of 12,138 probe sets with present calls in at least 10 out of 20 animals. Thirteen genes fulfilled additional criteria (I) log expression > 6, (II) present in all 10 bulls of the group "High IMF", and (III) expression difference ≥ 1.3. All 13 genes were significantly up-regulated in the "High IMF" group. Among them, 6 genes belonged to gene sets defined by De Jager et al. (4). SCD (stearoyl-CoA desaturase) and INSIG1 (insulin induced gene 1) are members of the gene set for fatty acid synthesis whereas FABP4 (fatty acid binding protein 4, adipocyte), THRSP (thyroid hormone-responsive protein) and CIDEC (cell death-inducing DFFA-like effector c) belong to the gene set for triacylglyceride synthesis and storage. ACLY (ATP citrate lyase) belongs to the gene set of PPARgamma-signaling. Further genes assigned to above gene sets were increased in the "High IMF" group of our study but did not reach significance level. Next we selected 4 genes (THRSP, CIDEC, INSIG1 and ACLY) for verification of differential expression by RT-qPCR. Additionally, two putative, functional candidate genes for fatness traits not represented on the microarray were analyzed.

FNDC5 (fibronectin type III domain-containing protein 5) was recently proposed as related to muscle mass and obesity in human and mice (8, 9) and ZNF423 (zinc finger protein 423) was identified as potent promoter of adipogenesis in cattle (10).

Table 4: Validation of differentially expressed genes by RT-qPCR

Gene symbol	Fold change "High" vs. "Low"	
	Microarray	RT-qPCR
THRSP	6.06	6.34
CIDEC	3.22	4.31
INSIG1	1.78	2.07
ACLY	1.58	$1.55^{p=0.08}$
ZNF423	n/a	0.91
FNDC5	n/a	0.92

The results of RT-qPCR confirmed largely the expression differences revealed by microarray. Expression of THRSP, CIDEC and INSIG1 was significantly increased in the "High" group. The fold-changes were in the same magnitude like observed in the microarray analysis. The differential expression of ACLY however, was confirmed only as trend although the fold changes corresponded well. Both functional candidates, FNDC5 and ZNF423, were not differentially expressed between both groups (Table 4).
Ingenuity pathway analysis (IPA) of differentially expressed genes revealed significant enrichment only of genes related to lipid metabolism (Fig. 1).
This result conforms to the assignment of the candidate genes to the gene sets proposed by De Jager et al. (4). The concordance of results from both studies indicate that the genes identified here represent true candidates for marbling traits independent of the cattle population investigated. Further genes with a trend to differential expression in both groups of cattle could not be assigned to pathways or functional groups by IPA. However, a trend to increased expression was observed for genes related to cytoskeletal organization and cell expansion (PAK3 - p21 protein [Cdc42/Rac]-activated kinase 3; CAMTA1 - calmodulin binding transcription activator 1, MYLK - myosin light chain kinase; S100A10 - S100 calcium binding protein A10) in the "High IMF" group. This indicates a relationship between increased expression of genes of these functional classes and altered cellularity of IMF in high-marbled cattle.

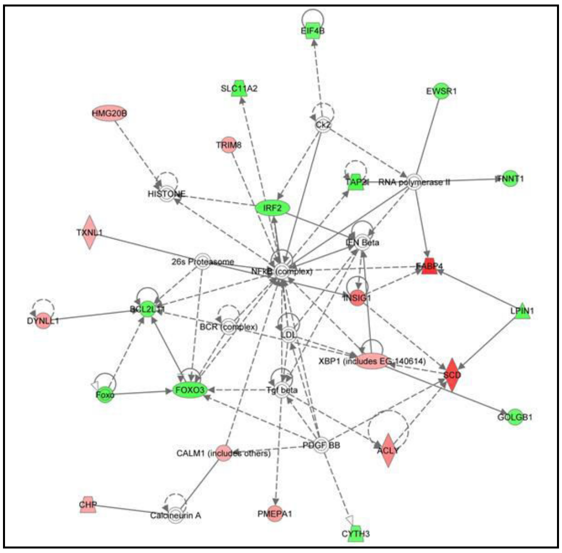

Fig. 1. Differentially expressed genes in pathway "lipid metabolism" (red: up-regulated; green: down-regulated)

Correlation analysis between individual gene expression levels of the investigated candidates and IMF revealed significant relationships for THRSP (r = 0.51), CIDEC (r = 0.56), INSIG1 (r = 0.48), and ACLY (r = 0.48). These correlation coefficients are higher than those reported by De Jager et al. (4) in a larger group (n = 48) for these genes (r = 0.14 – 0.30). Since IMF content is closely related to the fat cell parameters measured in our experiment, similar correlations exist between gene expression levels and these traits (r = 0.44 – 0.52, $p < 0.05$).
The bovine candidate genes were then analyzed on existing expression data in human tissues (GeneCards, 11). Comparison of gene expression levels between human skeletal muscle and adipocytes revealed three groups of genes. SCD and FABP4 are expressed predominantly in adipocytes (ratio adipocytes vs. skeletal muscle = 50 – 55 - fold). Thus higher expression values for these genes are likely to be caused by increased adipocyte number in skeletal muscle tissue rather than by increased expression in single adipocytes. A second group of genes (CIDEC, INSIG1, ACLY) are characterized by a 13 – 20 – fold higher expression in adipocytes than in muscle. Again, a higher number of adipocytes in muscle of bulls with increased expression of these genes may account for a significant part of the group differences. In contrast, THRSP is only 2-fold higher expressed in adipocytes compared to skeletal muscle. This makes it

likely, that the observed 6-fold increase in gene expression is not caused by higher adipocyte number to a large amount.
The genomic interval on bovine chromosome 29 where THRSP is located was recently identified as QTL for marbling (12). Furthermore, data from different cattle populations indicate that an increased expression of THRSP at different ontogenetic stages is related to marbling in cattle (13, 14).

IV. CONCLUSION

Most differently expressed genes, identified in a sample of this experimental F_2 cross, were predominantly expressed in adipocytes. Consequently, expression differences were likely to originate from increased adipocyte numbers in the muscle samples. In contrast, THRSP is expressed in muscle and fat cells similarly. The 6-fold increase of expression in the “High IMF” group qualifies THRSP as candidate gene for increased IMF deposition in bovine *M. longissimus*. Characterization of its physiological role in IMF deposition may shed light on this process.

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EFFECT OF CROSS BREEDING WITH HISPANO-BRETÓN AND BURGUETE ON PRODUCTIVE PARAMETER AND DYNAMICS OF GROWTH OF "GALICIAN MOUNTAIN" FOALS

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Abstract – The "Galician Mountain" (GM) horse is an autochthonous crossbred from the North of Spain adapted to an extensive production system. The objective was to study the effect of cross breeding with Hispano-Bretón (HB) and Burguete (B) on productive parameter and dynamics of growth of "Galician Mountain" foals. For this study, thirty-nine foals, twelve from crossing GM×HB and twenty-seven from crossing GM×B were used. Moderate biphasic profiles were observed from 120 days. The partial plateau phases and the total maximum growth or final asymptotes were experimentally well defined. The predictive ability of proposed equations to model the experimental data was high with a goodness of fit higher than 0.987. The sex of foals did not affect the growths and the differences among crossbreeds were not significant (*P*>0.05).

I. INTRODUCTION

Horsemeat is characterized by low fat, low cholesterol content and rich in iron [1]. This meat has a favorable dietetic fatty acid profile, with a high content of unsaturated fatty acids in relative to saturated acids and contains a greater proportion of components from the α-linolenic fatty acid family [2, 3]. These nutritional characteristics reveal that this type of meat may be considered as a new alternative in meat consumption.

The "Galician Mountain" horse is an autochthonous crossbred located in the mountains of Galicia (NW Spain), where it is born and raised. At the end of the 19th century and the beginning of the 20th century, horses of heavy breeds, such as Hispano-Breton and Burguete, were introduced into Spain to increase the corpulence of Spanish horses.

On the other hand, the success of animal production is mainly dependent on the minimization of the relationship between growths and nutrient costs. The correct description of growth data is especially important when a rigorous and predictive quantification is necessary in order to establish that animals are ready for market [4]. The most robust tool to address organism live-weight is obtained by the use of sigmoidal equations that permit to evaluate all the characteristic phases of animal growth [5].

The aim of this study was to assess the effect of cross breeding with Hispano-Bretón (HB) and Burguete (B) on productive parameter and dynamics of growth of "Galician Mountain" (GM) foals.

II. MATERIALS AND METHODS

II.1. Experimental design and animal management

For this study, thirty-nine foals, twelve from crossing GM×HB and twenty-seven from crossing GM×B were used. Animals were obtained from the experimental herd of Agricultural Research Centre of Mabegondo (Marco da Curra, A Coruña, Spain). Animals were reared with their mothers on pasture and were allowed to suck freely. Foals were weaned when they were 6-8 months old. Then, foals were fed with concentrate and pasture. Live weight of foals was recorded monthly during the experimental period.

II.2. Foals growth and mathematical modelling

The biphasic sigmoid trends obtained for the foals' growth were fitted to the sum of two logistic equations [6, 7]:

$$G = \frac{G_{m1}}{1+\exp\left[\mu_{m1}\left(\tau_1 - t\right)\right]} + \frac{G_{m2}}{1+\exp\left[\mu_{m2}\left(\tau_2 - t\right)\right]}$$

Another reparameterised format of this equation was also used to characterise all the phases of growth and obtain other parameters of biological interest [5]:

$$G = \frac{G_{m1}}{1+\exp\left[2+\frac{4v_{m1}}{G_{m1}}\left(\lambda_1 - t\right)\right]} + \frac{G_{m2}}{1+\exp\left[2+\frac{4v_{m2}}{G_{m2}}\left(\lambda_2 - t\right)\right]}$$

where, G_{m1} and G_{m2} are the maximum growths in the first and second sigmoid of the biphasic pattern (kg), respectively; μ_{m1} and μ_{m2} are the specific maximum rates of growth in the first and second sigmoid of the biphasic pattern (weeks^{-1}); τ_1 and τ_2 are the times required to achieve the half of the maximum growth in the first and second sigmoid of the biphasic pattern (weeks); v_{m1} and v_{m2} are the maximum rates of growth in the first and second sigmoid of the biphasic pattern (kg weeks^{-1}); λ_1 and λ_2 are the lag phases for the first and second sigmoid (weeks). In addition, $G_{mf} = G_{m1} + G_{m2}$ is the final maximum growth (kg) in the biphasic process (value of G when $t \rightarrow \infty$). In all cases, net growths of foals were normalized by subtracting the corresponding initial weights to all experimental data.

2.3. Numerical methods and statistical analysis

Growth of foals were modelled by minimisation of the sum of quadratic differences between observed and predicted values, using the non linear least-squares (quasi-Newton) method provided by the macro '*Solver*' of the Microsoft Excel spreadsheet. Confidence intervals from the parametric estimates (Student's *t* test) and consistence of mathematical models (Fisher's *F* test) and residual analysis (Durbin-Watson test) were evaluated by "*SolverAid*" macro (Levie's Excellaneous website:http://www.bowdoin.edu/~rdelevie/excellaneous).

III. RESULTS AND DISCUSSION

The results of the foal's growth from Burguete and Hispano-Bretón breeds are shown in Figure 1. The profiles fitted to the experimental data according to the model first equation or second equation is also displayed. Table 1 lists the values of the kinetic parameters and the statistical analyses performed on the numerical fittings. Moderate biphasic profiles were observed from 120 days. Nevertheless, these patterns were not so clear than previously reported for "Galician Mountain" and GM×HB crossing breeds [7]. The partial plateau phases and the total maximum growth or final asymptotes were experimentally well defined

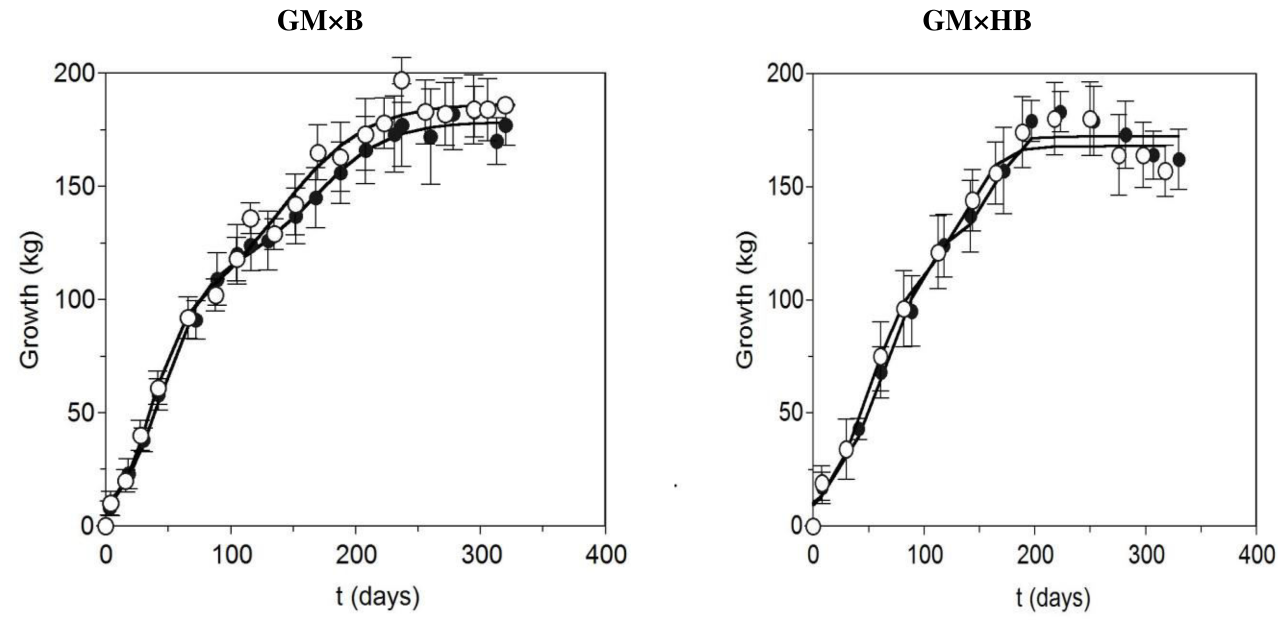

Figure 1. Growth of female (●) and male foals (○) from crossing GM×HB and from crossing GM×B

and, hence, the values of G_{m1}, G_{m2} and G_{mf} were statistically (P<0.05) significant (Table 1). The predictive ability of equation one or two to model the experimental data was high with a goodness of fit of not less than 0.987. All the parameters for GM×B growths were statistically (P<0.05) significant, and autocorrelation was not observed in the residuals (data not shown). However, in the case of GM×HB nearly half of the coefficients were not significant. The sex of foals did not affect the growths and the differences among crossbreeds were not significant (P>0.05). The mentioned growths (G_{mf} values) were lower than those obtained by GM and GM×HB breeds finishing with two amounts of feeding [7].

Table 1. Parametric estimations and confidence intervals (α = 0.05) corresponding to the first and second equation applied to predict the growth of foals.

	GM×B female	**GM×B male**	**GM×HB female**	**GM×HB male**
G_{m1}	114.07±25.26	129.43±18.03	140.16±27.07	119.49±57.20
v_{m1}	1.35±0.34	1.25±0.22	1.37±0.48	1.46±0.56
λ_1	13.65.±10.56	22.93±9.70	13.74 (NS)	9.49 (NS)
μ_{m1}	0.047±0.018	0.039±0.010	0.039±0.018	0.049±0.031
τ_1	55.90±12.36	74.78±10.99	65.03±16.74	50.50±26.79
G_{m2}	59.68±28.18	46.06±20.05	32.03±28.26	48.37 (NS)
v_{m2}	0.68±0.39	0.90±0.72	4.05 (NS)	0.90 (NS)
λ_2	133.58±55.67	179.92±38.68	167.25 (NS)	116.45±89.85
μ_{m2}	0.046±0.039	0.078±0.074	0.047 (NS)	0.075 (NS)
τ_2	177.42±24.71	205.55±16.88	171.15 (NS)	143.28±39.27
G_{mf}	173.75±6.79	175.49±5.99	172.18±7.25	167.86±7.02
R^2	0.993	0.994	0.987	0.987
P-value	<0.001	<0.001	<0.001	<0.001

NS: non-significant; R^2: coefficient of multiple determination; p-value from Fisher's F test (α = 0.05)

IV. CONCLUSION

The proposed equations demonstrated to be adequate to model and predict the bi-sigmoid trends of foal growths. Kinetic parameters obtained from them are a valuable tool for characterizing growth phases and assessment differences among sex, feed or growth conditions. However, in the present study sex did not show significant differences on growth parameters in both crossbreeds.

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CARCASS CHARACTERISTICS OF CROSSBREEDING BETWEEN *BOS TAURUS* AND *BOS INDICUS* BREEDS IN URUGUAY.

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Abstract. The objective of this research was the study the genetic type effect on carcass quality of 245 steers from Hereford (H) and F1 crosses, breeding sires of Angus (A), Salers (S) and Nellore (N) breed mated to Hereford dams. They were slaughtered at 730± 52 days at similar fat thickness. The highest weight of carcass was found in SH (250.5 kg) and NH (244.5 kg), while the lowest in AH (232,1 kg) crosses and H (222.8 kg) steers (p<0.01). Dressing percentage varied from 53.2 % (H) to 54.5% (NH). The highest meat yield (65.9 and 65.6%) were recorded in NH and SH respectively, with the lowest share of separable fat (6.4%) in SH, while the lowest amount of bone (21.5%) in NH crosses (p<0.01). No significative differences were evident for percentage of high commercial value cuts between crosses.

I. INTRODUCTION

No single cattle breed has all attributes that are needed to produce beef efficiently in all environments and to meet the requirements of all markets It is important to recognize that breed differences and rankings can vary due to such factors as sampling effects, environmental effects and production system (including end-point criteria). In many situations, the breed type of the cow herd must be matched to available resources and environmental constraints of the individual production unit. In either case, the genetic type best suited for cow herd production efficiency might not be optimal for postweaning production or meat traits (1). Substantial between -breed variation exists for many carcass composition and meat quality characteristics. Numerous reports are available on the effects of crossbreeding on carcass and beef quality attributes in *Bos taurus* breeds of cattle reared in temperate environments (2). Many of these reports also include tropically adapted breeds in their comparisons. However, there are relatively few reports of breed effects on carcass and beef quality attributes of cattle grazed at pasture. The object of this study was to examine the carcass quality from Hereford, Angus x Hereford, Nellore x Hereford and Salers x Hereford Fl steers fed pasture

II. MATERIALS AND METHODS

Carcass traits were evaluated from 245 steers from Hereford pure breed and F1 crosses, breeding sires of Angus, Hereford, Salers and Nelore breed mated to Hereford dams. Steers were slaughter in a commercial packing plant at the same fat thickness, with a slaughter age of 730 ± 52 days. At slaughter, the carcasses were identify, weighed and stored during 24 h in a chilling chamber at a temperature of 4ºC. After chilling, the right half of the carcass was used to determine carcass length, (from the anterior edge of symphysis pubis to the middle of the anterior edge of the visible part of the first rib). From these measurements a carcass blockiness index was calculated. This index expresses the relationship between hot carcass weight (kg) and carcass length (cm) as follows: Blockiness index = hot carcass weight *100 / carcass length. High values indicate high muscular development (3). Dressing percentage for an individual animal was defined as hot carcass weight divided by liveweight. Fat thickness was determined at P8 point (4). After a 48 h chill at 4 °C, the right side of each carcass was quartered between 10^{th} and 11^{th} rib into a 3-rib hind quarter and the remaining fore quarter. From the hindquarter the thin flank and the lateral ribs portion was removed generating the pistola cut. Left pistola of each carcass was fabricated into boneless retail product, lean tream, fat tream and bone. The pistola was dissected into 10 separate commercial joints: *tenderloin*; striploin; *Top Sirloin*, *tri-tip*; *rump cap*; outside; inside; *knuckle*; *Heel muscle*; and *shank* specified in INAC Hand-book (5). Striploin, tenderloin and Top sirloin were taken as "valuable cuts". Saleable beef yield consisted of the 10 primal cuts and manufacturing meat with all bone removed. Data were analyzed by variance analysis of, GLM procedure of SAS.

III. RESULTS AND DISCUSION

Hereford (H) purebred reached the lowest slaughter weights, differing from Salers Hereford (SH) while Nellore - Hereford (NH) and Angus-Hereford (AH) crosses achieved intermediate weights (Table 1).

Table1. Slaughter weight, carcass weight and carcass dressing

	Slaughter weight (Kg.)	Carcass Weight (Kg.)	Carcass dressing (%)
p<f	p<0.01	p<0.01	p<0.01
H	418.6 ±5.6 a	222.8 ±3.3a	53.2 ± 0.3 a
AH	437.9 ±3.5 b	232.1 ±2.1a	53 ± 0.22ab
SH	464.6 ±3.5 c	250.5 ±2.1b	53.9 ±0.2bc
NH	448.4 ±4.6 b	244.5 ±2.7b	54.5 ± 0.3 c

Later maturing breeds have lower carcass fatness and higher proportions of muscle and bone, requiring higher slaughter weight, to achieve the same degree of fatness. NH crosses achieved the highest carcass dressing differing performance with H purebred and AH crosses while SH crosses, reached intermediate values being different from the pure breeds, but not of other crosses evaluated. This major dressing carcass achieve by NH crosses is mainly due to a lower proportion of gut contents and a lower weight of gut and intestines (6). HS crosses reached the lowest carcass fat thickness, the best hindquarter /forequarter ratio, and with NH crosses greater Blockiness index than H, and AH crosses. (Table 2).

Tabla 2. Carcass blockiness index, hindquarter /forequarter ratio and carcass fat levels.

	Blockiness index(Kg. /cm.)	Hindquarter/Forequarter ratio	Fat thicknes P8 (mm)
p<f	p<0.01	p<0.01	p<0.01
H	1.6 ± 0.01 b	1.04± 0.07 b	10.7 ± 0.33 a
AH	1.6 ± 0.06 b	1.01 ± 0.05 a	10.9 ± 0.20 a
SH	1.81 ± 0.06a	1.06 ± 0.04 c	9.8 ± 0.20 b
NH	1.80 ± 0.08a	1.04 ± 0.05 b	10.9 ± 0.30 a

Carcass conformation decreased when carcass length increased, decreasing the width of it, thus losing compactness (7).

NH and SH crosses achieved the highest percentage of salable meat differing from H pure breed and AH crosses (Table 3).

Table 3. Pistola meat yield and valuable cuts proportion.

	Saleable meat yield (%)	Valuable cuts (%)
p<f	p<0.01	ns
H	63.9 ± 0.4 a	21.3 ± 0.1
AH	64.6 ± 0.2 a	21.4 ± 0.1
SH	65.6 ± 0.2 b	21.6 ± 0.1
NH	65.9 ± 0.3 b	21.7 ± 0.1

This higher meat yield was explained in NH crosses by a lower bone percentage and in SH crosses by a lower percentage of fat trim (Table 4). Differences between breeds in meat yield are generally attributable to the levels of carcass fat. Despite this and in cases in which different breeds types are evaluated even at the same fat level, differences can be explained in terms of a greater muscle / bone ratio (8)

Table 4. Pistola percentage of Bone and fat trim.

	Bone (%)	Fat (%)
p<f	p<0.01	p<.0.01
H	21.9 ± 0.2 ab	7.2 ± 0.2a
AH	22.3 ± 0.1 a	7.1 ± 0.1a
SH	22.0 ± 0.1 ab	6.4 ± 0.1b
NH	21.5 ± 0.1 b	7.05 ± 0.2ab

Valuable cuts differed between breeds when evaluated at constant age and weight, while at the same slaughter end, the previously differences tended to disappear (6,9).

CONCLUSIONS

Carcasses of crossbreeding between 4 beef cattle reared in their typical production system have been characterized. In pastoral systems of Uruguay F1, crosses between *Bos Taurus* breeds such as Salers, and *Bos Indicus* breeds as Nellore with Hereford were superior in terms of carcass weight and carcass dressing than Hereford and Angus – Hereford steers. Salers and Nellore crosses provided an advantage of 1% and 1.7% over Hereford and Angus - Hereford crosses for pistol meat yield.

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ESTIMATION OF THE WEIGHT OF CARCASS TISSUES OF GROWING PIGS USING COMPUTED TOMOGRAPHY

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Abstract – The aim of the present work is to estimate carcass composition of live growing pigs with computed tomography images. For this purpose 20 pigs (Pietrain x (Landrace x Large White)) were enrolled, scanned and slaughtered at 30, 70, 100 and 120 kg target weight (n=5 per target weight). Scanning was performed with a General Electric Hi Speed Zx/I computed tomographic scanner (CT). Fat, muscle and bone total volumes were calculated as the sum of voxel volumes ranging respectively between -149 and -1, 0 and +140 and +141 and +1400 Hounsfield (HU). After scanning, pigs were slaughtered, and left half carcasses were cut and dissected. Dissected lean, fat and bone weights of the main cuts were obtained and related with the respective radiodensity volumes. These relationships were established using linear, quadratic and allometric regressions. From these results it was concluded that lean, fat and bone can be estimated using live pigs CT images and this without removing the viscera.

I. INTRODUCTION

Estimating carcasses composition would allow the meat industry to optimize processes, to increase benefits and to satisfy consumer demands. The knowledge of pig carcass composition in live pigs during growth would help breeding and nutritional companies to produce the desired product. Carcass characteristics depend on several factors such as genetics, gender, feeding or management [1,2].

Computed tomography (CT) is a non invasive technology based on X-rays that allows visualizing and quantifying tissues of live animals and carcasses. The X-rays are attenuated in their way through the body. The degree of the attenuation depends on the density of the tissues and it is measured in Hounsfield units (HU). Because lean, fat and bone have different densities, HU values allow to differentiate between tissues. CT has been applied to estimate carcass composition of live animals and carcasses [3,4,5].

The aim of the present study was to estimate carcass composition in live growing pigs using computed tomography images.

II. MATERIALS AND METHODS

Animals and CT scanning procedure

A total of 20 pigs (Pietrain × (Landrace × Large White)) were used in the present study. Pigs were reared in the experimental farm of IRTA (Monells, Girona, Spain) and fed *ad libitum* in a two-phase feeding program. Five pigs were CT fully scanned at each of the following live weights: 31.4±2.2 kg, 67.7±1.8 kg, 100.5±1.5 kg and 123.1±3.8 kg live weight.

The scans were performed with a General Electric HiSpeed Zx/I CT. Pigs were previously anaesthetized and placed in a specific PVC cradle for easy transportation to the device installations (Figure 1). Acquisition conditions were: axial, matrix 512x512, 140 kV, 145 mA, 7 mm-thick at the lowest weight and 10 mm-thick at the rest of weights, and displayed field of view between 300 and 460 mm, depending on the volume of the animal.

Figure 1. Scanning of a live pig with a computed tomography device.

Carcass cutting and dissection

After the scans the pigs were slaughtered following the standard procedures. At 24 h *post mortem* left half carcasses were cut following Walstra and Merkus [8] procedure. Then, lean, fat and bones of the main cuts (loin, ham, belly and shoulder) were separated by a trained butcher and weighed. The entire tenderloin was also added to the amount of lean)

Image treatment

The distribution of voxels, based on the Hounsfield (HU) scale, was obtained from all the CT images of each pig, without the cradle and with viscera, and analyzed with the VisualPork software [6,7]. Frequency of voxels was transformed to volume by means of the displayed field of view, slice thickness and matrix. Volume between -149 and -1 HU values were classified as fat, values between 0 and 140 HU as lean and values between 141 and 1400 HU as bone. These volumes were used as predictors in the statistical analysis. Distribution of volume depending on HU values for the lean and fat area is presented in Figure 2.

Statistical analysis

Three different types of regression equations were performed to estimate the amount of lean, fat and bone weight of the four main cuts (tenderloin was added to the lean): (1) linear regression ($y=a+b\cdot x$), (2) quadratic regression ($y=a+b_1\cdot x+b_2\cdot x^2$), and (3) allometric regression ($y=a\ x^b$, linearized as $\log y = \log a + b\cdot\log x$). Predictors were the volume of lean for the lean weight, the volume of fat for the fat weight and the volume of bone for the bone weight.
Data analysis was performed with the REG procedure of SAS software (version 9.2; SAS Institute Inc., Cary, NC, USA). Dependent variables were weighed by the inverse of the standard deviation of the residuals at each target weight. To validate the models the mean of the residuals, the residual standard deviation and the correlation between predicted variables and residuals were studied. Moreover the root mean square error (RMSE) was calculated as:

$$RMSE = \sqrt{\frac{\Sigma(y_i - \hat{y}_i)^2}{n}}$$

where y_i is the dissected value, $\hat{y}_i$ the predicted value and n the number of observations.
The RMSE of prediction was obtained by cross validation leave-one-out (RMSEPCV) by means of a SAS macro adapted from those of Caseur et al. (2003).

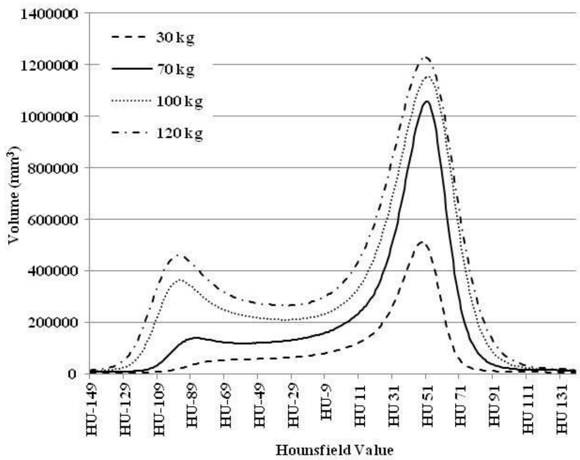

Figure 2. Volume distribution depending on Hounsfield values and target weight of the scanned live pigs.

III. RESULTS AND DISCUSSION

Averaged lean content was 14532 g, the averaged fat content was 5488 g and the averaged bone content was 1922. Thus, the mean of the residuals and the residual standard deviation were used to evaluate the goodness of fit of the equations and they were particularly low (Table 1). Furthermore, the correlations between residuals and predicted values were always close to zero indicating the lack of prediction biases. Figures 3, 4 and 5 show the relationship between the volumes and the weight of the different tissues. All the RMSE and RMSEP were quite similar. But the lowest RMSEP (in absolute value) for the prediction of the bone weight was obtained with the linear approach. Nevertheless, although it seems linear, it is possible to see that for lean weight, quadratic and allometric approaches gave the lowest RMSE and the lowest RMSEP, respectively. For the weight of the fat, quadratic approach produced the lowest RMSE and RMSEP. However, the magnitude of the errors between the different approaches was not very high.

Table 1 Goodness of fit for the different statistical approaches.

	Mean[a]	r.s.d.[b]	r[c]	RMSE	RMSEP
Lineal					
Lean	-22.6	399.4	0.07	389.9	410.8
Fat	-8.3	288.6	-0.08	281.4	312.7
Bones	-4.3	89.0	0.04	86.9	94.3
Quadratic					
Lean	-7.1	382.5	-0.01	372.9	414.5
Fat	6.8	270.4	0.00	263.6	305.8
Bones	-3.3	88.4	0.00	86.2	102.7
Allometric					
Lean	13.7	386.3	-0.05	376.7	396.8
Fat	-29.2	301.3	-0.21	295.1	328.2
Bones	-2.7	90.1	0.08	87.9	95.2

[a] Mean of the residuals; [b] standard deviation of the residuals; [c] Coefficient of correlation between r.s.d. and predicted variables; RMSE: root mean square error; RMSEP: RMSE of prediction by cross-validation leave-one-out.

IV. CONCLUSION

It is concluded that the amount of different tissues such as lean, fat and bone can be estimated using CT images of live pigs, without the necessity of removing the viscera.

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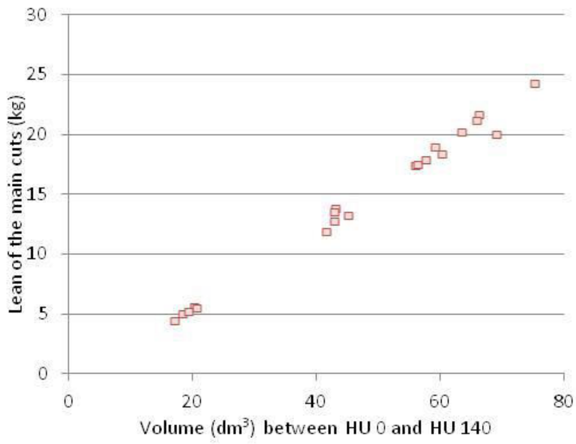

Figure 3. Relationship between the weight of lean of the main cuts from dissection and the volume of lean from CT images of live pigs.

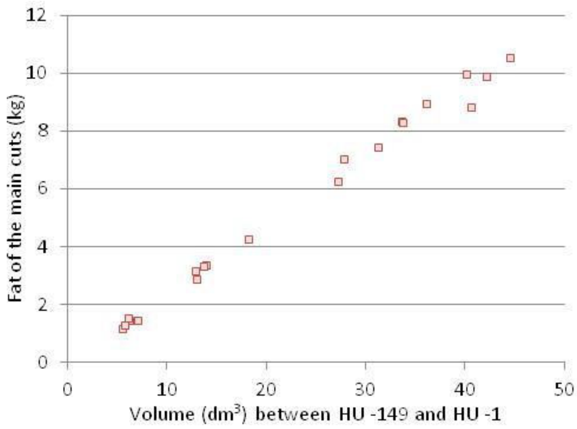

Figure 4. Relationship between the weight of fat of the main cuts from dissection and the volume of fat from CT images of live pigs.

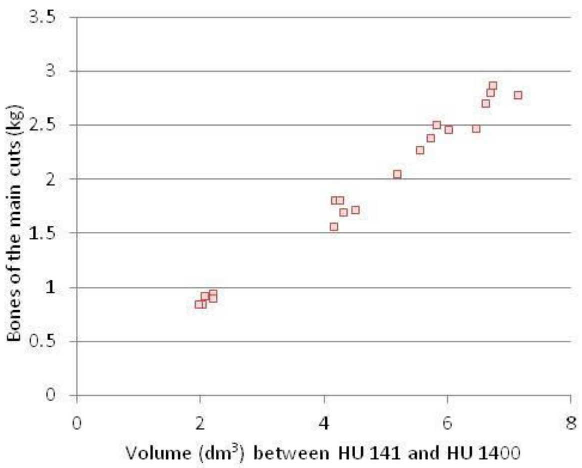

Figure 5. Relationship between the weight of bones of the main cuts from dissection and the volume of bones from CT images of live pigs.

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SELECTION FOR INTRAMUSCULAR FAT CONTENT AND CORRELATED RESPONSES ON CARCASS AND MEAT QUALITY TRAITS IN RABBITS

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Abstract - A divergent selection experiment for intramuscular fat content (IMF) in *Longissimus* muscle (LM) in rabbits was carried out during 5 generations. Direct and correlated responses in body weight, chilled carcass weight, reference carcass weight, scapular fat, perirenal fat, meat to bone ratio, color parameters in carcass and LM, pH of LM and fatty acid (FA) composition of the LM were estimated as the differences between lines in the fifth generation. Response to selection for IMF was successful, representing the difference between high and low lines 27.7% of the mean. Carcass quality was affected by selection for IMF, producing an increase in dissectible fat content, a slight decrease in meat to bone ratio and modifications in color parameters. Meat quality was also affected showing modifications in color and FA composition of the LM.

I. INTRODUCTION

Intramuscular fat content (IMF) plays an essential role in meat quality. However, few studies have been focused on increasing IMF by selection. Sapp *et al.* (1) in cattle, Schwab *et al.* (2) in pigs and Suzuki *et al.* (3) in a multitrait experiment also in pigs, showed that genetic improvement is feasible, but no experiments in rabbits have been performed hitherto. Selection for IMF can change carcass quality; for example, in pigs, selection for IMF lead to correlated deposition of fat, deteriorating carcass quality (2). Rabbit meat is characterized by its lower fat content and favorable FA composition compared to other meats (4). Moreover, rabbits are an excellent model for genetic studies in other livestock species due to their reduced generation interval and low cost of carcasses. The aims of this study are to evaluate the selection response and correlated responses on carcass and meat quality traits of a divergent selection experiment for intramuscular fat content of the *Longissimus* muscle in rabbits.

II. MATERIALS AND METHODS

Data. A total amount of 986 data from 5 generations of a divergent selection experiment for IMF of *Longissimus* muscle (LM) in rabbits were used in this study. Animals came from a synthetic rabbit line. The base population consisted of 13 males and 83 females. High (H) and low (L) lines had approximately 8 males and 40 females per generation. Selection was based on the phenotypic value of IMF measured in 2 full sibs of the candidate (a male and a female). Selection pressure on females was approximately 20% per generation on average. Males were chosen within families to avoid inbreeding. Litters were homogenized at birth up to 9 kits per litter. Rabbits were reared collectively from weaning to 9 weeks of age and were fed *ad libitum* with a commercial diet. Animals were evaluated after slaughter at 9 weeks of age, and chilled for 24h at 4ºC. Then, LM was excised, minced, freeze-dried and scanned with near infrared spectroscopy (NIRS). The IMF of LM was expressed as g/100g of muscle on a fresh basis. Body weight (BW), chilled carcass weight (CCW) and reference carcass weight (RCW) (5) were recorded. Scapular (SF) and perirenal fat (PF) were excised and weighted. The left leg was dissected to obtain the meat to bone ratio. Color parameters L*, a*, b* of the carcass were measured on the surface of the fourth lumbar vertebra, and color of the meat was measured at the seventh lumbar vertebra transversal section at the LM. Euclidean distance Delta E (ΔE) was calculated (6). Muscle pH was measured 24 hours *post mortem* in the LM at the level of the fifth lumbar vertebra. Fatty acids (FA) composition of the LM was determined by NIRS (7), and was expressed as a percentage of total FA. All experimental procedures involving animals were approved by the Universitat Politècnica de València Research Ethics Committee, according to Council Directives 98/58/EC and 2010/63/EU.

Statistical analysis. Descriptive analyses were performed using the whole data set, after correcting data by line-generation, sex and parity order effects. Response to selection for IMF and correlated responses were estimated as the differences between H and L lines in the fifth generation (62 and 52 rabbits, respectively). A model with the previous effects and a common litter effect was employed. Bayesian inference was used. Normal priors for the common litter effects and flat priors for the remaining effects were used.

III. RESULTS AND DISCUSSION

Table 1 presents descriptive statistics of the carcass and meat quality traits. Tables 2 and 3 present descriptive statistics for FA composition in LM.

Table 1. Descriptive statistics of IMF, BW and carcass and meat quality traits.

Trait	Mean	SD	CVx100	Nºof animals
IMF[1]	1.08	0.16	14.8	980
BW[2]	1719	156	9.1	986
CCW[3]	988	100	10.1	984
RCW[4]	783	84	10.8	984
SF[5]	4.03	1.22	30.3	980
PF[6]	8.48	3.72	43.9	984
M/B[7]	4.60	0.52	11.3	703
CL*[8]	54.2	2.44	4.5	986
Ca*[9]	3.21	0.86	-*	986
Cb*[10]	0.61	1.37	-*	954
LML*[11]	53.1	2.50	4.7	985
LMa*[12]	3.76	1.01	-*	985
LMb*[13]	1.14	0.76	-*	985
LMpH[14]	5.58	0.10	1.8	981

[1]IMF, intramuscular fat content of the *Longissimus* muscle (g/100g); [2]BW, body weight (g); [3]CCW, chilled carcass weight (g); [4]RCW, reference carcass weight (g); [5]SF, scapular fat content (g); [6]PF, perirenal fat content (g); [7]M/B, meat to bone ratio of the hind leg; [8]CL*, lightness, [9]Ca*, redness and [10]Cb*, yellowness of the carcass surface; [11]LML*, lightness, [12]LMa*, redness, [13]LMb*, yellowness and [14]LMpH, pH of the *Longissimus* muscle.*CV non estimable.

Table 2. Descriptive statistics of SFA, MUFA, PUFA (expressed as a percentage of total fatty acids) and fatty acid ratios of the *Longissimus* muscle.

Trait	Mean	SD	CVx100	No. of animals
SFA[1]	36.0	2.0	5.6	959
MUFA[2]	24.0	2.2	9.1	950
PUFA[3]	38.9	3.5	9.0	959
n-6/n-3[4]	5.69	0.41	7.3	959
PUFA/SFA	1.08	0.11	9.8	959

[1]SFA=C14:0+C15:0+C16:0+C17:0+C18:0; [2]MUFA=C16:1+ C18:1n-7+C18:1n-9; [3]PUFA=C18:2n-6+C18:3n-3+C20:2n-6+ C20:3n-6+CC20:4n-6+C20:5n-3+C22:4n-6+C22:5n-3+C22:6n-3; [4]n-6=C18:2n-6+C20:2n-6+C20:3n-6+C20:4n-6+C20:5n-6+ C22:4n-6; n-3 =C18:3n-3+C20:5n-3+C22:5n-3+C22:6n-3.

Table 3. Descriptive statistics of individual fatty acid composition (expressed as a percentage of total fatty acids) of the *Longissimus* muscle.

Trait	Mean	SD	CVx100	Nºof animals
C14:0	1.29	0.43	33.3	903
C15:0	0.49	0.02	4.3	908
C16:0	19.8	1.7	8.4	959
C16:1	1.33	0.59	44.1	847
C17:0	0.79	0.05	6.6	905
C18:0	8.70	0.59	6.8	959
C18:1 n-7	1.70	0.13	7.4	908
C18:1 n-9	20.7	1.7	8.2	959
C18:2 n-6	25.2	2.0	7.8	959
C18:3 n-3	1.74	0.23	13.0	959
C20:2 n-6	0.32	0.05	15.0	908
C20:3 n-6	0.65	0.12	18.2	908
C20:4 n-6	5.80	0.95	16.4	959
C20:5 n-3	1.80	0.35	19.2	908
C22:4 n-6	2.23	0.36	16.3	908
C22:5 n-3	0.67	0.17	24.9	883
C22:6 n-3	2.23	0.59	26.5	873

Response on IMF and correlated responses in carcass and meat quality traits are shown in Table 4. Response to selection for IMF was successful, being the difference between lines in the fifth generation 0.30g/100g muscle, representing 27.7% of the mean. Other experiments were also successful in cattle (1), in pigs (2), and also in a multitrait selection experiment in pigs (3).

The BW and carcass body weights showed a slightly negative correlated response with IMF. The probability of the difference in BW between H and L lines being different from zero (P) was 0.96, although it represented a low percentage of the mean (3.7%). Schwab *et al*. (2) did not observe response in growth traits when selecting for IMF in porcine.

There are evidences that fat deposits have increased, particularly PF. The difference between lines in PF was 2.61, representing 30.8% of its mean. Schwab *et al.* (2) showed a low positive correlated response in adipose tissues when selecting for IMF in pigs and Sapp *et al.* (1) did not obtained any response in fat deposits when selecting for IMF in cattle. Selection for IMF can deteriorate carcass quality due to correlated increase in adipose deposits. Nevertheless, total dissectible fat content in rabbit carcass is low, about 3% of the carcass at 9 weeks of age (8), thus this correlated response is not relevant in practice. There is some evidence that the meat to bone ratio was slightly lower in the H line (P=0.96). In pigs, Schwab *et al.* (2) showed a negative correlated response in loin muscle area when selecting for IMF. Nonetheless, Sapp et al. (1) did not find a response in ribeye area trait in cattle after selection for IMF.

Table 4. Responses to selection for IMF and correlated responses on BW and carcass and meat quality traits estimated as the differences between high and low lines in the fifth generation.

Trait	D[1]	P[2]	$HPD_{95\%}$[3]
IMF[4]	0.30	1.00	[0.24, 0.37]
BW[5]	-64.3	0.96	[-139, 8.5]
CCW[6]	-15.5	0.74	[-60.7, 30.9]
RCW[7]	-10.9	0.70	[-50.7, 27.6]
SF[8]	0.31	0.88	[-0.21, 0.82]
PF[9]	2.61	1.00	[0.95, 4.29]
M/B[10]	-0.26	0.96	[-0.54, 0.05]
CL*[11]	-1.18	0.98	[-2.27, -0.05]
Ca*[12]	0.10	0.72	[-0.27, 0.45]
Cb*[13]	-0.27	0.81	[-0.88, 0.34]
CΔE[14]	1.27	1.00	[0.17, 2.39]
LML*[15]	-1.22	0.99	[-2.33, -0.09]
LMa*[16]	0.33	0.95	[-0.05, 0.74]
LMb*[17]	0.00	0.51	[-0.33, 0.31]
LMΔE[18]	1.28	1.00	[0.25, 2.36]
LMpH[19]	0.05	0.99	[0.00, 0.09]

[1]D, median of the marginal posterior distribution of the difference between high and low lines; [2]P, probability of D being greater than zero when D>0 and probability of D being lower than zero when D<0; [3]$HPD_{95\%}$ highest posterior density region at 95% of probability; [4]IMF, intramuscular fat content of the *Longissimus* muscle (g/100g); [5]BW, body weight (g); [6]CCW, chilled carcass weight (g); [7]RCW, reference carcass weight (g); [8]SF, scapular fat content (g); [9]PF, perirenal fat content (g); [10]M/B, meat to bone ratio of the hind leg; [11]CL*, lightness, [12]Ca*, redness, [13]Cb*, yellowness and [14]CΔE, color distance of carcass surface; [15]LML*, lightness, [16]LMa*, redness, [17]LMb*, yellowness, [18]LMΔE, color distance and [19]LMpH, pH of the *Longissimus* muscle.

Rabbit meat is usually commercialized as a whole carcass and to a less extent as retail cuts, thus carcass color is important for consumers. Selection for IMF produced some modifications in carcass and meat color. Carcass and meat lightness were lower in the H line (P=0.98 and P=0.99, respectively). In contrast, Schwab *et al.* (2) observed a large positive correlated response in LML* when selecting for IMF in pigs. Redness traits Ca* and LMa* were higher in the H line, particularly LMa*. Yellowness was higher in the carcass of the L line, but showed no response in LM. Differences in color distance ΔE higher than 1 are considered the minimum that the human eye can detect (6). Differences higher than 1 in ΔE were found in carcass and meat, but highest posterior density intervals at 95% of probability were large. To our knowledge, no studies comparing differences in color with ΔE have been performed.

Although LMpH was greater in H line (P=0.99) with a difference between lines of 0.05, in practice this difference is not relevant. Schwab *et al.* (2) found no effect of selection for IMF on this trait, in porcine.

Tables 5 and 6 show correlated responses on FA composition of the LM. Saturated fatty acids (SFA) percentage did not present differences between lines. In contrast, selection for IMF modified percentages of monounsaturated fatty acids (MUFA) and polyunsaturated fatty acids (PUFA), showing H line higher values for MUFA percentage and lower values for PUFA percentage. The differences between H and L lines in PUFA/SFA and n-6/n-3 ratios were relevant, being negative for PUFA/SFA ratio (P=1.00) and positive for n-6/n-3 ratio (P=1.00). In a review, De Smet *et al.* (9) display that an increment in IMF leads to modifications in FA composition, explained by the different FA composition of the two major lipid fractions, phospholipids and triacylglycerols, and by the relative contribution of these fractions to total lipids when IMF increases.

Table 5. Correlated responses to selection for SFA, MUFA, PUFA (expressed as a percentage of total fatty acids) and fatty acid ratios of the *Longissimus* muscle estimated as the differences between high and low lines in the fifth generation.

Trait	D[1]	P[2]	$HPD_{95\%}$[3]
SFA[4]	0.03	0.53	[-0.86, 0.97]
MUFA[5]	4.56	1.00	[3.56, 5.54]
PUFA[6]	-4.77	1.00	[-6.42, -3.16]
n-6/n-3[7]	0.35	1.00	[0.15, 0.52]
PUFA/SFA	-0.13	1.00	[-0.18, -0.08]

[1]D, median of the marginal posterior distribution of the difference between high and low lines; [2]P, probability of D being greater than zero when D>0 and probability of D being lower than zero when D<0; [3]$HPD_{95\%}$ highest posterior density region at 95% of probability; [4]SFA=C14:0+C15:0+C16:0+C17:0+C18:0; [5]MUFA=C16:1+C18:1n-7+ C18:1n-9; [6]PUFA=C18:2n-6+C18:3n-3+C20:2n-6+C20:3n-6+C20:4n-6 +C20:5n-3+C22:4n-6+C22:5n-3+C22:6n-3;[7]n-6=C18:2n-6+C20:2n-6 +C20:3n-6+C20:4n-6+C20:5n-6+C22:4n-6n-3=C18:3n-3+ C20:5n-3 +C22:5n-3+C22:6n-3.

Table 6. Correlated responses to selection for individual fatty acid composition (expressed as a percentage of total fatty acids) of the *Longissimus* muscle estimated as the differences between high and low lines in the fifth generation.

Trait	D[1]	P[2]	$HPD_{95\%}$[3]
C14:0	0.52	1.00	[0.30, 0.72]
C15:0	0.01	1.00	[0.00, 0.02]
C16:0	0.15	0.65	[-0.58, 0.92]
C16:1	0.89	1.00	[0.60, 1.19]
C17:0	-0.07	1.00	[-0.10, -0.05]
C18:0	-0.74	1.00	[-1.01, -0.47]
C18:1 n-7	-0.08	0.99	[-0.13, -0.02]
C18:1 n-9	3.51	1.00	[2.75, 4.29]
C18:2 n-6	-2.58	1.00	[-3.49. -1.65]
C18:3 n-3	0.08	0.92	[-0.03, 0.19]
C20:2 n-6	-0.06	1.00	[-0.08, -0.04]
C20:3 n-6	-0.21	1.00	[-0.27, -0.16]
C20:4 n-6	-1.61	1.00	[-2.06, -1.17]
C20:5 n-3	-0.43	1.00	[-0.58, -0.27]
C22:4 n-6	-0.67	1.00	[-0.84, -0.51]
C22:5 n-3	-0.04	0.99	[-0.17, -0.02]
C22:6 n-3	-0.41	1.00	[-0.70, -0.14]

[1]D, median of the marginal posterior distribution of the difference between high and low lines; [2]P, probability of D being greater than zero when D>0 and probability of D being lower than zero when D<0; [3]$HPD_{95\%}$ highest posterior density region at 95% of probability.

Individual FA showed a similar pattern as for the FA groups. Difference between H and L lines for individual SFA, C14:0, C15:0 and C16:0 were positive and for C17:0 and C18:0 were negative. Due to their different behaviors, the total percentage of SFA did not show differences between lines. Individual MUFA C16:1 and C18:1n-9 were higher in the H line. In pigs, a moderate high genetic correlation between IMF and C18:1n-9 was reported (10). Individual PUFA C18:2n-6 was higher in the L line, as well as the remaining n-6 fatty acids. All n-3 fatty acids were also higher in the L line, except C18:3n-3, which was lower.

IV. CONCLUSION

A successful experiment of divergent selection for IMF was carried out. In the fifth generation, the difference between H and L lines represented 27.7% of the mean. Carcass quality was affected by selection for IMF, producing an increase in dissectible fat content, a slight decrease in meat to bone ratio and modifications in color parameters. Meat quality was also affected showing modifications in color and FA composition of the LM.

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COLOR, pH, DRIP LOSS, OXIDATIVE PARAMETERS AND MINERAL CONTENT IN URUGUAYAN *CRIOLLO* LAMB MEAT

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Abstract- Muscles *Longissimus dorsi*, *Psoas major* and *Gluteus medius*, from six *criollos* lambs, were evaluated for pH, color, drip loss, lipid and protein oxidation, heme and non heme iron content after 0, 14 and 21 days of ag ing. Also, mineral content as, Se, Cu, Mn and Mo were measured in unaged meat. Results showed that pH values was not affected by muscle or aging, whereas *L, *a** and *b** color parameters, and drip loss was slightly higher with the aging time. TBARS increased with aging in all muscles. Carbonyls, heme and non heme iron was not affected by aging nor difference was observed between muscles. Se content was more elevated in *Gluteus medius* muscles, while Cu, Mn and Mo content were not different. In conclusion, meat from *Criollo* lamb showed interesting technological and nutritional parameters to place it as a promising meat product in the local and regional market.**

I. INTRODUCTION

The *Criollo* sheep is a local breed that has been adapted to the environmental conditions of Uruguay since more than four centuries. Currently, the *Criollo* sheep is found in small flocks that are raised by farmers in low-value pastoral fields (1). Through these animals, producers maintain a form of traditional breeding transmitted generationally (2). His meat is highly appreciated locally, consumed within the rural setting or is sold in small local circuits. The study of the technological and nutritional qualities of this kind of meat is necessary to obtain information for a better understanding of this differential product. The obtained information will help producers to promote their production locally and regionally. That also will help the conservation of a genetic group that is endangered in Uruguay. This is the first time than the technological and nutritional parameters of *Criollo* meat were investigated for the breed present in Uruguay. So, the aim of the present work was the determination of pH, color, drip loss, lipid and protein oxidation, heme and non heme iron content after 0, 14 and 21 days of aging. Also, mineral content as, Se, Cu, Mn and Mo were measured in unaged meat.

II. MATERIALS AND METHODS

Six *Criollo* lamb males, weighting 24.75±1.03 kg were selected in a farm in the Rocha ‘region of Uruguay and transported to a commercial authorized abattoir, where they remained overnight (approximately 12 h) in the lairage pens with cemented walls and non-skid floors. Water was freely available but there was no access to feed. All the followed procedure were in accord to the official rules for transport, sacrifice and dressing of lamb in Uruguay, and special recommendation for handling this kind of animals (3). The research protocol has been approved by the Animal Experimentation Ethics Committee of the University of the Republic (Udelar). After dressing, the carcasses entered a freezing tunnel that led to a chill room at 2–3 °C, with an air velocity of 0.5 m/s, until 24 h post-mortem. Cold carcass weight (average 11.45 ±2.34 kg) .was taken after 24 h in the cold room. After chilling for 24 h, the right *Longissimus dorsi* (LD), *Psoas major* (PM) and *Gluteus medius* (GM) muscle were removed, and each one was divided into three sections. One is considered as unaged and the two others were vacuum-packaged and aged for 14 and 21 days, respectively, at 2 ° C. In unaged and aged samples the following measures were realized. pH was measured using a penetration Ph-meter LT Lutron pH-201. Color was measured using a portable CR-10 Minolta colorimeter, based on the CIE L*a*b* system. For all samples, the measures were carried up after 30 min of bloom at 3 °C. Drip loss was measured by the determination of the weight difference with 2.5 g of meat samples (4). Lipid oxidation was determined by TBARS method (5) with some modifications (6). Protein oxidation was estimated by the reactions between carbonyls and (*2,4*-dinitrophenylhydrazine) with the resulting formation of a Schiff base which produces hydrazone, quantified by spectrophotometer at 360 to 385 nm (6). The determination was carried out by the method of Mercier et al. (7). Heme iron was measured by method proposed by Hornsey (8) adapted by Ramos et al., (9). Non heme iron was analyzed by the Ferrozine method described by Ahn et al. .Se, Cu, Mn and Mo were measured according to Cabrera et al. (10) using an atomic absorption spectrophotometer with graphite furnace (Analyst 300, Perkin Elmer, USA)

III. RESULTATS AND DISCUSSION

Results about the technological characteristics are presented in Table 1. No muscle main effect was observed for color, pH and drip loss ($p>0.05$). An aging main effect was observed for color, L*, a*, b* ($p<0.001$). Lightness, redness and yellowness significantly increased with aging time. This effect was previously observed in aged vacuum- packaged lamb meat (11). pH values were under 6 for LD and GM, but PM showed pH higher 6. This differences were not significant between muscles (Table 1). The drip loss significantly increased with aging ($p<0.001$) but no difference was observed between muscles. For the oxidative parameters, lipid oxidation increased with the aging time, but no effect for muscles was observed (Table 2). Protein oxidation, were stable along the aging this results are indicative of a lower protein degradation principally the myoglobin (11). Heme and non heme iron were also stable during the aging time. For mineral content in unaged meat (Table 3), Se content but not Cu, Mn and Mo, showed a muscle effect. Indeed, GM has a significantly higher content of Se than LD or PM.

IV. CONCLUSION

Meat from *Criollo* lamb produced in Uruguay showed some interesting technological and nutritional parameters to place it as a promising meat product in the local and regional market. Indeed, this study, the first in the country, contributes to a better knowledge of meat quality of lamb carcasses from *Criollo* breed and provides data on the oxidative stability and mineral composition of this kind of meat

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Table 1. Color (L, a*, b*), pH and drip loss (%) in unaged and aged *Longissimus dorsi (LD), Psoas major (PM)* and *Gluteus medius (GM)* muscles from *Criollo* lambs.

	Days of aging								
	0	14	21	0	14	21	0	14	21
		LD			PM			GM	
L*	33.8 ±0.9	35.5 ±1.0	37.2 ±1.0	37.2 ±0.7	39.0 ±0.8	40.9 ±0.8	37.4 ±1.2	39.3 ±1.2	41.1 ±1.3
a*	18.7 ±1.1	19.6 ±1.1	20.5 ±1.2	18.0 ±0.8	19.0 ±0.8	19.9 ±0.9	19.7 ±0.5	20.7 ±0.6	21.7 ±0.6
b*	7.95 ±0.46	8.35 ±0.48	8.76 ±0.50	8.30 ±0.63	8.70 ±0.66	9.20 ±0.69	9.75 ±0.5	10.25 ±0.6	10.75 ±0.6
pH	5.77 ±0.04	5.75 ±0.04	5.75 ±0.03	6.07 ±0.1	5.88 ±0.2	6.05 ±0.1	5.84 ±0.05	5.80 ±0.04	5.82 ±0.05
Drip loss %	3.1 ±0.2	6.2 ±0.3	7.8 ±0.4	3.0 ±0.3	6.0 ±0.6	7.6 ±0.8	3.0 ±0.3	6.0 ±0.6	7.5 ±0.8
	Mains effects								
	L*, a*, b*, drip loss: Muscle ns Aging P < 0.001						pH: Muscle Ns Aging Ns		

Data are mean ± SEM. Mains effects for muscle and days of aging were analyzed by repeated measures ANOVA and post hoc Tukey test (P < 0.05) (NCSS, 2007). Ns= No significant.

Table 2. Lipids and protein oxidation, and heme and no heme iron content in unaged and aged *Longissimus dorsi, Psoas major* and *Gluteus medius* muscles from *Criollo* lambs.

	Days *post mortem*								
	0	14	21	0	14	21	0	14	21
	Muscles								
		Longissimus dorsi			*Psoas major*			*Gluteus medius*	
TBARS (mg MDA/ kg meat	0.64± 0.03	0.74± 0.18	0.90± 0.12	0.58± 0.04	0.71± 0.12	0.93± 0.11	0.52± 0.04	0.97± 0.09	0.96± 0.13
Carbonyl (nM NADPH/ mg prot)	0.50± 0.07	0.44± 0.05	0.39± 0.02	0.55± 0.09	0.54± 0.04	0.39± 0.04	0.43± 0.02	0.43± 0.05	0.44± 0.03
Heme iron (ppm)	16± 0.6	15.2± 1.0	14.9± 1.0	16.2± 1.2	16.3± 1.8	16.9± 0.8	16.3± 0.7	16.9± 1.3	16.4± 0.6
No heme iron (ppm)	0,63± 0,09	0,55± 0,09	0,55± 0,04	0,54± 0,08a	0,53± 0,02a	0,86± 0,08b	0,74± 0,07	0,65± 0,06	0,59± 0,08

Mains effects

TBARS (mg MDA/kg meat	Muscle: Ns	Aging: P<0.001
Carbonyl (nM NADPH/mg prot	Muscle: Ns	Aging: Ns
Heme iron (ppm)	Muscle: Ns	Aging: Ns
No heme iron (ppm)	Muscle: Ns	Aging :Ns

Data are mean ± SEM. Main effects for muscle and days of aging were analyzed by Repeated measures ANOVA and post hoc Tukey test (P < 0.05). Within the same muscles, different letters mean significant differences (P < 0.05) for aging duration. Ns=No significant.

Table 3. Minerals content in unaged *Longissimus dorsi* (LD), *Psoas major* (PM) and *Gluteus medius* (GM) muscles of *Criollo* lambs.

	Muscles			
	LD	PM	GM	Significance
Se (mg/kg)	0.261±0.03b	0.234±0.03b	0.415±0.08a	P < 0.05
Cu (mg/kg)	1.08 ± 0.16	1.38 ± 0.08	1.10 ± 0.08	Ns
Mn (µg/kg)	85.4 ± 7.4	98.7 ± 5	82.1 ± 5.9	Ns
Mo (µg/kg)	4.8 ± 1	4.8 ± 0.5	4.4 ± 0.7	Ns

Data are mean ± SEM. Different lowercase letters means a statistical difference by ANOVA one way and Tukey´s test (P < 0.05). Ns= No significant.

BEEF SENSORY ANALYSIS OF STEERS FROM DIFFERENT GENOTYPES FINISHED IN PASTURE OR IN FEEDLOT SYSTEM

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Abstract – Sensory evaluation is a useful technique applied in the food production chain to ensure its quality. The goal of this study was to evaluate the beef quality based on the sensory traits of steers from eight genotypes: Angus, Angus x Caracu, Brangus, Hereford x Angus, Hereford, Nelore x Angus, Nelore x Brangus and Nelore, finished in feedlot or pasture. It was assessed the intensity of color, aroma, flavor, pork-like flavour, tenderness, juiciness and fatness in *Longissimus dorsi* (LD) and *Semitendinosus* (SE) muscle. Significant effects (P<0.05) were observed between the finishing systems and among genotypes in both muscles. The color demonstrated significant effect for genotypes in SE and in the interaction genotype*finishing system in LD. The finishing system were significantly divergent in flavor and pork-like flavor in SE, this last one also presented significant effect in LD. Feedlot samples had more pork-like flavor when compared to pasture ones. The juiciness were significant different among the genotypes. The samples more tender were the European breeds and its crossbreeds in LD. The fatness in LD showed genotype and finishing system effects. The feedlot system samples showed fatter when compared to the pasture ones. Feedlot system affected negatively flavor characteristic in both muscle beef samples.

I. INTRODUCTION

Sensory analyses can be applied to fill up the needs and demands of consumers, measuring the beef quality traits of the livestock production in different breeds along distinct feed systems. Those factors can affect aroma, flavour, tenderness, fatness, among others. Thus it is necessary to determine which genotypes, according to the production system, yield beef with better qualitative traits. In order to assess the effect of different genotypes finished in different feed systems on beef quality, was carried out sensory evaluation of meat from steers Angus (ANAN), Angus x Caracu (ANCR), Brangus (BNBN), Hereford x Angus (HHAN), Hereford (HHHH), Nelore x Angus (NEAN), Nelore x Brangus (NEBN) and Nelore (NENE), finished in pasture or in feedlot system.

II. MATERIALS AND METHODS

It was assessed the beef quality traits through sensory analyses in LD (between 12th and 13th rib) and SE beef samples from 8 genotypes: ANAN, ANCR, BNBN, HHAN, HHHH, NEAN, NEBN and NENE. The steers were kept at Embrapa Southern Region Animal Husbandry (CPPSUL) fields and finished in ryegrass plus oat grass pasture or in feedlot system (60%corn silage plus 40% animal feed). For the sensory evaluations, the previously frozen samples were thawed at 4°C for 24 hours and the beef sample preparation followed the AMSA [1] recommendations. Then, samples were roasted until reach 70°C internal temperature, cut parallel to the fiber muscle into 1.5cm^3 pieces and were offered to the assessors at 60°C in monadic way in individual chambers. The sensory technique of analyses followes the Meilgaard *et al* [2] recommendations. The intensity of each attribute (color, aroma, flavor, pork-like flavor, tenderness, juiciness and fatness) was assessed in *L. dorsi* (LD) and *Semitendinosus* (SE) muscle in different sessions, using a 9 cm scale, being 0 = little intense and 9 = very intense. The exception was for tenderness trait, which was consider 0 = extremely tender and 9 = extremely tough. The assessments were done at Meat Science and Technology Laboratory of CPPSUL by 8 trained assessors. The sensory panel has three years training for meat sensory evaluation. The type III *F* statistics were used to test the fixed effects in the model (Y=μ+genotype+finishingsystem+genotype*finishingsystem+animal(genotype*finishingsystem)+assessor(data)+residue). When significant, respective least squares means were compared using T Test (P<0.05).

III. RESULTS AND DISCUSSION

Mean values and the effects in data analyses are shown in Table 1 and 2. Significant effects (P<0.05) were observed between the two finishing systems and among genotypes in both muscles.

Table 1- Beef sensory traits assessed in *Semitendinosus* muscle at different genotypes in pasture or feedlot.

Sensory trait	ANAN	ANCR	BNBN	HHAN	HHHH	NEAN	NEBN	NENE	Finishing system		Effect I P
									Pasture	Feedlot	
Color	4.13	4.27	4.40	4.41	3.69	4.75	4.83	3.95	4.15	4.46	B*FS|0.01
Aroma	4.95	4.02	4.68	4.58	4.61	4.09	4.74	4.26	4.495	4.497	ns
Flavour	4.92	4.31	4.12	4.55	4.88	3.86	4.33	4.04	4.31	4.44	ns
Pork-like flavour	0.75	0.98	0.64	0.75	0.73	1.12	0.24	0.34	0.35^{a}	1.04^{b}	FS|0.01
Tenderness	3.9^{a}	2.87^{ab}	2.66^{a}	3.84^{a}	4.5^{ac}	5.04^{ac}	5.18^{ac}	5.05^{ac}	4.33	3.93	B |0.05
Juiciness	4.46	5.53	4.72	4.76	4.47	4.26	4.19	3.44	4.49	4.47	ns
Fatness	2.96^{a}	3.53^{ac}	2.54^{ab}	3.31^{abc}	2.34^{ab}	2.93^{ab}	2.43^{ab}	1.90^{b}	2.43^{a}	3.06^{b}	B,FS|0.01, 0.005

[a]same letters in same line do not differ significantly. [ns] not significant

Table 2- Beef sensory traits assessed in *L. dorsi* muscle at different genotypes in pasture or feedlot.

Sensory trait	ANAN	ANCR	BNBN	HHAN	HHHH	NEAN	NEBN	NENE	Finishing system		Effect I P
									Pasture	Feedlot	
Color	3.83^{a}	5.02^{b}	3.47^{a}	4.56^{ab}	4.80^{abc}	4.18^{ab}	3.94^{ab}	2.92^{a}	4.20	3.98	B |0.01
Aroma	4.53	4.53	4.79	5.19	4.87	5.27	4.24	4.07	4.69	4.69	ns
flavour	4.48	4.38	4.52	4.93	5.01	4.01	3.63	3.76	4.74^{a}	3.69^{b}	FS I 0.03
pork-like flavour	1.06	0.86	1.67	0.59	0.57	1.21	1.13	0.98	0.59^{a}	1.42^{b}	FS I 0.01
tenderness	3.4	4.24	4.33	3.71	4.34	4.55	4.5	4.79	4.45	4.01	B*FS |0.03
juiciness	4.74^{a}	3.15^{b}	4.04^{ab}	5.19^{a}	4.32^{a}	2.79^{b}	3.79^{b}	3.41^{b}	3.86	4.00	B I 0.03
fatness	2.31	2.78	2.84	2.87	3.17	2.78	2.26	1.15	2.71	2.40	ns

[a]same letters in same line do not differ significantly. [ns] not significant

The color trait demonstrated significant effect for genotypes in SE (higher results for ANCR, HHAN, HHHH, NEAN and NEBN) and in the interaction genotype*finishing system in LD. No significant effect was found for aroma. There was no significant effect in flavor trait in LD. The finishing system caused significant effect in flavor and pork-like flavor in SE, this last one was also significant in LD. Feedlot samples had more pork-like flavor when compared to pasture ones. This finding can be justified by the intake of corn silage by the feedlot animals as the major portion of its diet. The juiciness were significant different among the genotypes. The genotypes ANAN, BNBN, HHAN and HHHH showed the better results in SE. The samples more tender were ANAN, ANCR, BNBN, HHAN and HHHH in LD. Those zebu breeds or zebu-crossbreeds presented beef less juicy in SE while in LD showed be less tender. The fatness in LD showed genotype and finishing system effects. The NENE genotype presented the thinner sample when compared to others. The feedlot system samples showed fatter when compared to the pasture ones.

Resconi *et al* [3] found similar results regarding to steers fed only concentrate plus hay which produced beef that had an inferior sensory quality because they had more pronounced off-flavors and was tougher. In other hand, those authors found significant differences in aroma and flavor between pasture and feedlot animals.

IV. CONCLUSION

Genotypes and feed systems affected beef sensory traits. The most remarkable finding was that feedlot system affected negatively flavor characteristic in both muscle beef samples.

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EVALUATION OF THE BEEF QUALITY OF YOUNG SENEPOL CROSSBRED HEIFERS UNDER TROPICAL GRAZING CONDITIONS

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In order to improve the commercialization of locally produced beef, a strategic supplementation regime and the percent of Senepol blood in beef heifers was evaluated. *Longissimus dorsi* samples were collected from a total of forty-four Senepol x Charolais x Charbray crossbred heifers under three dietary treatments (T1= grazing; T2= grazing plus light protein supplementation; T3= grazing plus heavy protein supplementation) for three slaughter years (2011, 2012 and 2013). Those were analyzed for intramuscular fat percentage and Warner-Bratzler Shear Force at 0 days (24 hrs *post mortem*) and after 14 days of aging. Our results showed improvement in tenderness of meat samples after 14 days of aging (4.77± kg, P=0.039). In 2013, T3 was superior in intramuscular fat percentage (3.84±0.39%; P<0.05). Also in 2013, more Senepol (More_S) heifers showed greater fat percentage than the less Senepol (Less_S). Also, More S showed a fat percentage increase depending on the plane of nutrition (P=0.006) and was superior to Less S in T2 but inferior in T1. Therefore, it seems that More S heifers presented better intramuscular fat percentage than Less S under light protein supplementation. Also, a 14 days aging period resulted in a tenderness improvement irrespective of the amount of Senepol inheritance.

I. INTRODUCTION

The Senepol breed was introduced in the Caribbean in the early 1900s by crossing Red Poll bulls with N'Dama cows (1). The breed was developed to meet the specific requirements of the tropical Caribbean environment by combining the heat tolerance and insect resistance of the N'Dama breed with the gentle disposition and overall productivity of the Red Poll. (2). This breed has proven to be an important addition to the genetic pool of cattle that are bred and used for beef in Puerto Rico and other parts of the world like Brazil, Colombia, Venezuela, Panama and even Australia. Also, Senepol crossbreds are considered to be very productive, hardy and adaptable to tropical conditions.

There is little information available that compares the meat quality of traditional pasture-fed Senepol crossbred beef, especially for heifers. In Puerto Rico grass finished young heifers of any breed, that reach processing weight at an age of 20 to 24 months receive an unreasonably large price discount at the feeder and slaughter levels. This price discount is jeopardizing the economic viability of local cow-calf operations. The grazing performance, carcass characteristics and beef quality of young grass-fed heifers needs to be characterized if feeder heifer prices, at any level, are going to improve. The objectives of this study were to determine carcass characteristics, beef quality, and intramuscular fat percentage from Senepol crossbred cattle pasture-fed and to evaluate the effect of aging over beef tenderness.

II. MATERIALS AND METHODS

A total of forty-four Senepol (S) x Charolais (CHA) x Charbray (CH) crossbred heifers were evaluated between December 2010 and September 2013. Treatments consisted of 1) grazing at an average stocking rate (SR) of 1.30 head/acre (T1); 2) grazing at a SR of 1.32 head/acre plus supplemental feeding of a protein supplement at 0.50% of live weight (T2); and 3) grazing at a SR of 1.33 head/acre plus supplemental feeding at 0.70% of live weight (T3). Each year, at the start of spring, pastures received 181.4 kg/acre of 15-5-10 of fertilizer. Average on test weights in T1, T2 and T3 were 232.1, 229.4, and 230.4 kg/head, respectively at approximately 9 to 10 months of age. After approximately of 277.3 days of grazing, average final live weights were 370.4, 388.9 and 403.2 kg for T1, T2 and T3, respectively.

At the end of each the grazing period heifers from each treatment were slaughtered at 17-18 months of age, estimated by the number of permanent incisive (3). Animals were slaughtered at a USDA inspected commercial abattoir. After processing, carcass measurements were taken and the left hindquarter was dissected into muscle, fat, bone and fascia/tendon (connective tissue) groups at the Meat Science Laboratory at UPR Mayaguez. Two roasts (10 cm thick) were harvested from the *Longissimus dorsi* (LD) muscle posterior to the 12th rib from the left half of the carcass. One roast was analyzed immediately (0 days) and stored at −28°C under vacuum-packaging. The other was vacuum-packed and aged for 14 d at 5°C. After the 14 d of aging, the roasts were moved and stored at -28°C until quality assessment and analysis could be completed. Prior to analysis, meat samples were ground in a mini food processor (Premium, model PMC155) and stored at -28°C until analysis. Samples were defrosted at 5°C, from which approximately 2 grams were weighed and placed in fat filter bags. These were dried in oven at 102°C (Narco, 630) for 24 hrs and the weight was recorded. The filter bags were placed in the ANKOM XT10 Extractor (ANKOM Technology, Macedon, NY, USA) for ether extraction of fat. The filter bags where oven dried for 15-30 minutes. Afterwards, they were weighed and the crude fat percentage was calculated using the AOCS Official Procedure Am 5-04 (4).

Warner–Bratzler shear force (WBSF) analysis was conducted according to AMSA's guidelines (5). The roasts were thawed overnight at 5 _ C after each aging period, and roasted at 177□C in a convection oven (Vulcan 60SC-2DQ) to an internal temperature of 74 _ C. Cooked roasts were then cooled and three cores of 1.27 cm in diameter were cut parallel to the muscle fibers. Each core was sheared three times using a Warner-Bratzler machine (Salter, 3000). This procedure was also applied to the roasts prior to cooking (raw). The average measurements of nine cooked meat cores were used for subsequent analysis (5).

The experiment was conducted as a completely randomized design and the data was analyzed by the PROC GLM of SAS with slaughter year, dietary treatment and Senepol influence as independent variable in the model. Body weight at slaughter was used as a covariate in the model. Means were separated by LSD test of SAS Version 9.2.

III. RESULTS AND DISCUSSION

The WBSF values of both aging periods evaluated (0 vs. 14 d) are presented in Figure 1. Aging increased tenderness of meat samples with 0 d and 14 d of aging presenting WBSF values of 6.46±0.56 and 4.77±0.34 kg, respectively, P=0.039, in the meat samples. The meat tenderness is influenced by various factors such as the type of muscle evaluated (support or locomotive), intramuscular fat and *post mortem* proteolysis (6). Aging meat samples for 14 d allows enzymatic processes to take place and ultimately affects the integrity of the muscle fibers, which is directly responsible for changes in tenderness. Our findings agree with previous studies by Hanzelkovái1 et al. (7) and Bratcher et al. (8), which stated that the vast majority of tenderness improvement, based on WBSF readings, happens at two weeks of aging.

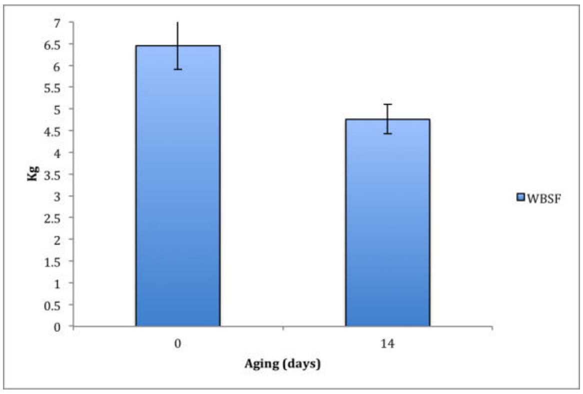

Figure 1. Mean values and standard errors of WBSF for 0 and 14 days of aging in crossbred beef heifers' meat samples

There was an interaction (Fig. 2; P<0.006) between year and breed, which affected the intramuscular fat percentage. For years 2011 and 2012 there were no significant differences in fat percentage associated with breed (P>0.05). Meanwhile, during 2013, More_S animals showed greater fat percentage values than their Less_S counterparts (3.47±0.25 and

2.29±0.28%, respectively). In animals with Less_S, we found that the fat percentage remains constant throughout all three years evaluated (1.92±0.20, 2.28±0.24, 2.29±0.28%, respectively; P>0.05). Meanwhile, animals with More_S influence showed an increase of fat percentage in 2013.

An evaluation of the different factors associated with the environment and handling of the animals could explain the effect of slaughter year. Some of the environmental factors affecting the fat percentage each year are the amount of precipitation, humidity and available minerals and nutrients for the different types of forage fed to the animals. However, we cannot provide a concise explanation for the variability between the years.

Senepol animals are characterized by having a smaller body frame than Charolais and Charbray cattle, and smaller animals have a predisposition of reaching sexual maturity earlier. The fat deposition in these animals is accelerated by sexual maturity and diet (9). Using slaughter weight as a covariate, our data indicated that animals with Less_S influence had meat with a fairly constant fat percentage in all years evaluated. Whereas, animals with More_S influence showed an increase associated with the amount of supplementation offered. Carcasses from animals with heavier supplementation are expected to have greater adipose accumulation regardless of breed as documented in Sterman-Ferraz et al. (10).

An interaction between slaughter year and grazing period (P=0.0047) affecting fat percentage (Fig. 3) was significant. No significant difference between the dietary treatments offered to the animals in this study (P>0.05) could be observed for the year 2011. For animals evaluated in 2013, there were significant differences for all three diets with T3 having an overall greater fat percentage with 3.84±0.39%. Animals in T1 showed no difference (P>0.05) in 2011, 2012 and 2013 (1.72±0.27, 2.14±0.34 and 1.77±0.29%, respectively). The T2 heifers in the last two years, 2012 and 2013, had no differences (P>0.05) but data for 2011 showed to be different for fat percentage (1.97±0.23%, P=0.005). The greater fat percentage was found in T2 throughout the three years experimental period (1.97±0.23, 2.9±0.35, 3.03±0.39%, P<0.001). Although, T3 showed no significant differences in years 2011 and 2012 (1.72+0.25 and 1.99±0.31%; P>0.05) for fat percentage, in 2013 differences were observed (3.84±0.39%; P<0.05).

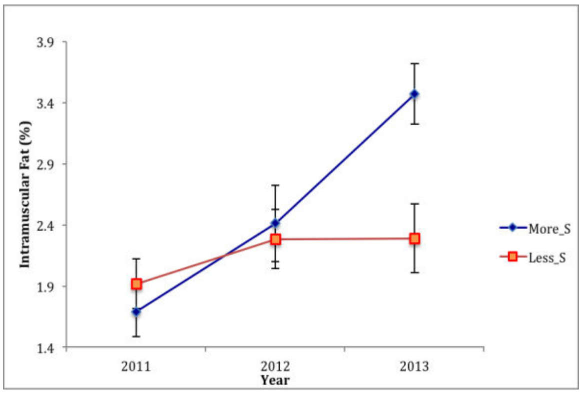

Figure 2. Mean values and standard errors of fat percentage for the different genotypes (Senepol influences) during years of study in crossbred heifers.

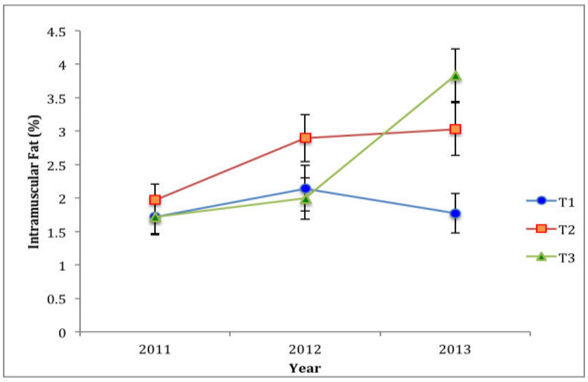

Figure 3. Mean values and standard errors of fat percentage for the different experimental diets during three years of study in crossbred beef heifers.

The interaction between Senepol influence and treatment (P<0.001) over the fat percentage of the meat samples is presented in Fig. 4. For animals with More_S influence we observed significant differences between all three treatments. On the other hand, animals with Less_S influence had significant difference between T1 and T2 and between T1 and T3 (1.52±0.30, 3.54±0.29 and 1.52±0.30, 2.50±0.20, respectively). Pasture-fed animals (T1) showed significant difference between More_S and Less_S influence (1.52±0.30 and 2.23±0.23%, respectively). The T2 heifers showed differences with a much higher fat percentage in animals with More_S influence (3.54±0.29%, P<0.001). Animals offered T3, had constant fat percentage for both Senepol influences: Less_S and More_S (2.53±0.27 and 2.50±0.20%, respectively; P<0.001).

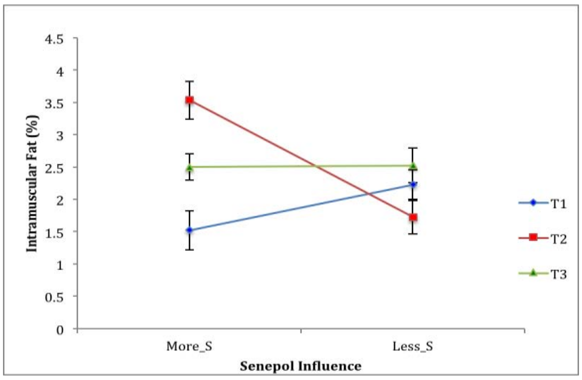

Figure 4. Mean values and standard errors of fat percentage for the experiment diets in the different genotypes of crossbred beef heifers.

IV. CONCLUSION

The present study showed that improvements in tenderness of the meat, the most important characteristic for consumers, could be achieved by allowing the meat to age for a period of two weeks. Furthermore, meat from animals with More_S influence and light supplemental feeding showed to have an effect on intramuscular fat deposition. The use of Senepol crossbred heifers should be taken into consideration as a model for improvement of carcass characteristic and beef quality in the tropics. The adaptability to high temperatures and very humid conditions displayed by these animals is key in an effort to further develop the commercialization of local beef, specially under grazing and limited supplementation conditions.

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GROWTH, CARCASS AND MEAT QUALITY EVALUATION OF POLWARTH AND CROSSBREED LAMBS

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Abstract – The objective of this study was to evaluate the influence of sire breed (Polwarth=P, Poll Dorset=PD and East Friesian=EF) on growth, carcass and meat quality traits of lambs born to wool type ewes. A flock of multiparous Polwarth ewes was mated with connected P, EF and PD rams during three consecutive years. PD cross lambs had higher weaning, slaughtering and carcass weight and growth from birth to weaning and from weaning to slaughtering compared to the other biotypes evaluated. They also presented a higher subcutaneous fat depth at the GR point and weight of valuables cuts (Leg and Rack) but these differences disappear when the comparisons are done at constant carcass weight. PD cross lambs also presented a higher proportion of superior carcass (S) according to INAC system. EF cross lambs presented a lower subcutaneous fat depth at the GR point independently of the carcass weight that is a particular genetic characteristic of this breed. The lambs carcasses produced in this experiment achieved most quality parameters for our international markets with the exception of the subcutaneous fat depth which is under the market requirements. Some alternatives to increase the GR are presented and discussed.

I. INTRODUCTION

In the last two decades, important changes took place in the Uruguayan sheep productive systems. Meat and specially lamb has consolidated as a productive alternative, complementing and in many cases, attaining more relevance than wool, which was for many decades, the principal product of Uruguayan traditional sheep systems [1]. In this scenario, reproductive efficiency, lambs growth rate and the price farmers gets for their product (associated to the product´s quality) are the most important parameters that insides on the farmers´ economic equations [2].

The incorporation of maternal and terminal biotypes has demonstrated to be a tool of high utility to improve the reproductive and productive performance of Uruguayan flocks [3].

With these objectives, new breeds have been introduced to our country. One of them was Poll Dorset that is used worldwide under terminal crossbreeding due to its high growth rate and meat and carcass quality obtained in these lambs.
East Friesian breed, also introduced to our country, is used under intensive lamb production systems as a maternal biotype due to its good maternal ability and high ovulation rate.
The objective of this study was to evaluate the influence of sire breed (Polwarth, Poll Dorset and East Friesian) on lambs´ growth, carcass and meat quality traits.

II. MATERIALS AND METHODS

The experiment was done at the Sheep Unit of INIA La Estanzuela, Uruguay (34°19´57´´S and 57°40´07´´W), from March 2004 until November 2007 including three generations of lambs evaluated.

A flock of multiparous Polwarth ewes (wool type) was mated with Polwarth (Ideal) (P), East Friesian (EF) and Poll Dorset (PD) rams during three consecutive years, using a minimum of three rams of each breed per year. One ram of each breed used one year, was used the following one as a genetic link.

All lambs obtained by the cross breeding (PDxP, EFxP and PxP) were evaluated from birth until slaughtering. The traits evaluated included:
Growth traits: birth weight of live born lambs (BWT, n=507), weaning weight at 72 ± 17 days of age (WWT, n=507), and slaughtering weight at 382 ± 22 days of age (SWT, n=496), growth from birth to weaning (GBW, n=507), and from weaning to slaughter (GWS, n=496).

Carcass traits: Hot Carcass Weight (HCW, kg, n=234); tissue depth (as an indicator of carcass fatness) (GR, mm, n=298**;** weights of the most valuable meat cuts: French Rack (Rack, g, n=232),

and boneless Leg (Leg, g, n=234) weights were measured according to Robaina [4].
Lambs carcasses were classified with the subjective grading system developed by the National Meat Institute (INAC) and used for heavy lambs with four classes of conformation (decreasing from S-excellent, P-good, M-medium, to I-poor) and three classes of fat finish (increasing from 0-total absence to 2-excesive covering).

Meat quality traits: Meat color was measured on the cut surface of the *Longissimus dorsi* with a Minolta Chroma meter (Model C-10). Parameters (n=130) L* (relative lightness), a* (relative redness) and b* (relative yellowness) were assessed 60 minutes after the surface was exposed. Warner Braztler Shear Force (WBSF, kgF, n=130) was measured on *Longissimus dorsi* muscle after five days of aging.

For statistical analysis, the breed type means were estimated by analysis of variance with the fixed effects of the breed type (B, 3 levels), year of birth (Y: 2004, 2005, 2006), sex (S: female or male), birth type (BT: single or multiple =twin or triplet), and their interactions (BxS, BxBT; SxBT). Sire effect within breed type was included as random effect. For the analysis of the WWT and GBW the age at weaning was used as covariate. Likewise, for the analysis of SWT and carcass and meat quality traits age at slaughter was included as covariate. For GWS evaluation, days between weaning and slaughtering date were included as covariate.
All traits were analyzed assuming a normal distribution using the procedure MIXED of SAS (Statistical Analysis System, Version 9.2, 2008).
In addition, an alternative weight adjusted (wt adj) model for GR, Rack and Leg with HCW covariate was used to evaluate valuables cuts ratio.

III. RESULTS AND DISCUSSION

PDxP and EFxP lambs had higher BWT ($p<0.05$; Table 1) compared to PxP lambs (0.340 y 0.360 kg respectively) without difference between cross lambs. This difference should be to an additive and individual heterosis effect since their mother were of the same breed, age and consequently similar maternal ambient.

Table 1. Least square means of breed groups for birth (BWT), weaning (WWT), and slaughtering weight (SWT), growth from birth to weaning (GBW), and from weaning to slaughter (GWS).

Trait	PxP	EFxI	PDxP
BWT (kg)	4.26 ^{b}	4.62 ^{a}	4.60 ^{a}
WWT (kg)	17.5 ^{c}	18.6 ^{b}	19.5 ^{a}
GBW (kg)	13.3 ^{c}	14.0 ^{b}	15.0 ^{a}
SWT (kg)	40.5 ^{c}	45.8 ^{b}	50.3 ^{a}
GWS (kg)	23.1 ^{c}	27.3 ^{b}	30.6 ^{a}

Note: Different letters in superscript (a, b, c) indicate significant differences in results of the same row ($p<0.05$).

PDxP lambs had 0.9 kg of weight more than EFxP and 2.0 kg more than PxP ($p<0.05$;Table 1).
Similar tendencies were reported in lambs´growth rate between birth and weaning. For this variable, PDxP lambs were 1.0 and 1.7 kg heavier than EFxP and PxP lambs respectively, while the latter lambs were 0.7 kg lighter than EFxP ($p<0.05$; Table 1). In both cases, the difference can be attributed to the genetic merit of the lamb´s sire breed since maternal ambient and the feed availability were the same for all lambs´ biotypes.

At slaughtering PDxP lambs were 9.8 and 4.5 kg heavier than PxP and EFxP lambs respectively ($p<0.05$). Similar results were reported in the growth between weaning and slaughtering. Indeed, in that period, PDxP lambs were 3.3 and 7.5 kg heavier ($p<0.05$; Table 1) than EFxP and PxP lambs respectively

PDxP lambs produced 2.7 kg more of carcass weight compared to EFxP ($p<0.05$) which produced 2.8 kg more of carcass than PxP lambs. Under comparable conditions, similar results have been presented by Ganzábal *et al*. [3] and Bianchi *et al* [5].

In this experiment, the GR (mm) was significantly higher ($p<0.05$) in the PDxP lambs compared to the other evaluated biotypes (Table 2). However, the differences observed in the PDxP and PxP lambs are due to the carcass weight of each biotype. Since, this difference disappeared ($p>0.05$) when HCW was used as a covariable in the statistical model. On the other hand, the carcasses of EFxP lambs had significantly less ($p<0.05$) GR, even when corrected by HCW. These differences were of 2.6 and 1.5 mm between EFxP and PDxP or PxP respectively. East Friesian is a breed recognized to have less subcutaneous fat compared to other breeds and this, has been demonstrated under Uruguay conditions by

Ganzábal *et al.* [3]. This attribute of the EF, assures that even when the carcass are of very high weight, they would not be devaluated because of over fattening.

Table 2. Least square means of breed groups for carcass and meat quality traits.

Trait	PxP	EFxI	PDxP
HCW (kg)	17.0 c	19.8 b	22.5 a
GR (mm)	6.7 b	7.6 b	12.3 a
GR wt adj (mm)	9.2 a,b	7.7 b	10.3 a
Rack (kg)	0.421 c	0.483 b	0.573 a
FR wt adj (kg)	0.494 a	0.483 a	0.500 a
Leg (kg)	1.7 c	2.0 b	2.2 a
Leg wt adj (kg)	1.95 a	1.97 a	1.93 a
WBSF (kg)	2.98 a	2.97 a	3.19 a
L*	40.6 a	39.6 a	40.3 a
a*	14.8 a	14.1 a	13.6 a
b*	10.9 a	10.1 a	10.9 a

Note: Different letters in superscript (a, b, c) indicate significant differences in results of the same row ($p<0.05$).

In Figure 1 are presented all carcasses belonging to the three biotypes identified according to their HCW and depth of the subcutaneous fat (GR). At the same time, it can be observed in the squares the requirements for each variable for the most important markets for lamb meat produced in Uruguay according to Lema [6].

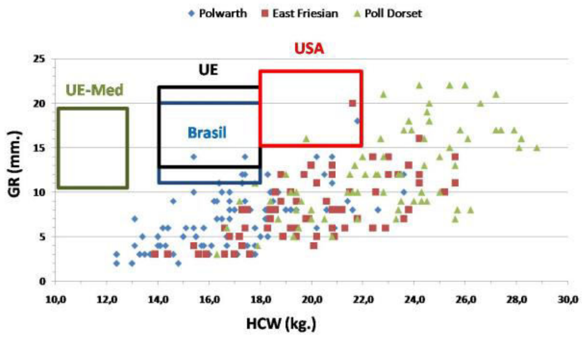

Figure 1. Association between HCW (kg) and GR (mm) by breed and differentiation according to international market supplies.

In general terms, the carcasses obtained in this experiment have GR under the requirements' of most International markets. Possibly, Uruguayan rearing and finishing systems (long periods, based on pastures and lambs slaughtered close to the year of age) privilege growth and not fattening, achieving only some fat by the end of the process.

The Leg (P) and French Rack (FR) were the cuts chosen for the carcass evaluation since they are the cuts that most incidences have on the value of the carcass [7]. The carcasses belonging to PDxP lambs presented Leg and Rack heavier ($p<0.05$) than EFxP lambs (200 and 90 g, respectively) and the latter lambs had Leg and Rack 300 and 62 g heavier ($p<0.05$) than PxP lambs (Table 2). However, these differences were entirely due to the higher carcass weight and not to a higher proportion of these valuable cuts since, this difference disappeared when HCW was used as a covariable in the statistical model.

There were no differences ($p>0.05$) between the three biotypes for meat quality. In all three treatments, the average levels of tenderness were within desirable levels and under the hardness levels considered as a problem [8].

Table 3. Distribution (%) of carcasses according to INAC system (conformation and fat classification) by breed group.

Trait	PxP	EFxI	PDxP
M	14	9	1
P	85	85	70
S	1	6	29
0	1	1	0
1	86	85	55
2	13	14	45

In Table 3, it can be observed that PDxP lambs presented near 30 % of S carcasses, compared to 6 and 1 % for EFxP and PxP lambs. PDxP lambs only presented 1 % of carcasses M compared to 9 and 14 % for the two other biotypes. Within grading, PDxP lambs presented 45 % of carcasses 2-type that is considered optimum. For the same scoring, EFxP and PxP lambs presented 14 and 13 % of 2-type carcasses respectively. All the biotypes presented carcass with adequate finishing levels according to the INAC system [9]. This seems to be a contradiction with the information presented in Figure 1, where a high percentage of carcasses do not fulfill the requirements of the most important export markets.

IV. CONCLUSION

According to the results obtained in this experiment, PD breed is an interesting option to be used as a terminal cross on wool type ewes to increase lambs growth rate and carcass conformation, specially under pastoral conditions as in Uruguay. According to the characteristics of the carcasses obtained with low levels of GR; it should be considered reducing the slaughtering age by using more precocious breeds with higher growth rate and fattening or consider the use of other complementary feeds like grains during finishing. These managements would avoid prolonged periods of rearing, that slows the productive system and generates difficulties in the finishing of the carcass.

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PERFORMANCE AND CARCASS QUALITY OF STEERS WITH DIFERENT NUTRITIONAL LEVELS AND PARENTAL EPD FOR RIB EYE AREA

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Abstract – Experiment objective was to measure the effect of 2 Winter Stoker Growth Rates (WSGR; low and high) and the utilization of two groups of sires with different values of Expected Progeny Differences (EPD) for Rib Eye Area (REA; high and average) on the yield and quality of meat of Hereford steers. 86 steers grouped in two blocks according to weaning weight were used and sorted in a factorial design of 2x2 generating 4 treatments. After differential stoker, all animals grazed pastures with an herbage allowance of 5% of live weight per day. When animals reached 350kg of live weight, they started the finishing stage under lot feeding. Slaughtering was reached in average at 515 kg. High WSGR or progeny of sires of high REA increased carcass meat production. High WSGR increased Hot Carcass Weight (HCW) and yield. Sires with high REA generated animals with similar HCW to those with average REA but they had better carcass conformation since due to relation of the hindquarter to the forequarter and higher proportion of cuts. The animals of treatment high REA*high WSGR had better cutability than those of the other treatments.

I. INTRODUCTION

Under Uruguayan pastoral conditions, the critical moments for beef stockers are the first and second winter of life since climatic conditions and quantity and quality of native pastures do not permit adequate growth rates. Severe restrictions at these moments may affect the productive performance of the animals during their whole life. It has been demonstrated that a more efficient calf stocker determines a reduction in the slaughtering age, increasing the system efficiency [1].

Stocker cattle producers are primarily concerned with achieving optimum performance and profitability during their ownership phase but should also consider the effects of their production practices on subsequent finishing phase and carcass performance of the cattle they manage[2].

Sire selection criteria has a direct relation with the quality of the outcome product. Male sires with superior genetic merit for carcass traits will transmit part of that superiority to their progeny obtaining steers with better performance compared to steers born to bulls with less genetic merit. The Expected Progeny Differences (EPD) summarizes all available information into a prediction of genetic merit for an individual that can be used to make selection decisions[3].

The objective of the present work was to quantify the effect of different Winter Stoker Growth Rate (WSGR) and the utilization of male sires with different EPD for Rib Eye Area (REA) on carcass yield and quality.

II. MATERIALS AND METHODS

The information belongs to an experiment carried out between 2012 and 2014 at the Beef Unit of the Experimental Station “Alberto Boerger” of INIA La Estanzuela at 34º20’45 south latitude and 57º42’40 west longitude, Uruguay.

For the experiment, 86 Hereford calves born to 8 bulls selected by their EPD for REA were used; 4 sires for high and 4 sires for average values of REA EPD obtained from the PANAM genetic evaluation of the Hereford breed. Bulls for high and average EPD values are in the percentile 10 and 50 respectively.

The experimental design was a factorial 2 x 2 with two WSGR (low: 0.211 and high: 0.563 kg of daily live weight gain) and two different groups of EPDs for REA (high REA EPD and average REA EPD). The average weight of the calves at weaning was 175 kg. Within each sire group and before sorting them into the nutritional treatments, the calves were regrouped in two blocks according to the weaning weight, totalizing eight groups. These groups were kept separated from stocker until slaughtering.

During stocker, the calves were located in lot feeding pens and with the same area per animal of 15 m^2 and 70 cm of trough per head. The diet during stocker in the pens was made by 46% moha hay (*Setaria italica*), 19% corn grain, and 35% of sunflower meal. The animals were also provided with 70 g calcium carbonate and 10 g common salt per animal/day. The diet was the same for all animals and was calculated to cover protein requirements, having a concentration of 14.5% of Crude Protein (CP) and 2.23 Mcal of metabolize energy (ME) per Kg of dry mater (DM). The different daily growth rates were achieved by limiting the energy intake modifying the amount of feed given to the calves. The amount of the diet was adjusted every 14 days according to the average weight of the group and the target growth rate of the treatment. The animals were offered fresh water and minerals *ad libitum*. Before consuming the final diet, the calves were introduced to the diet for 15 days. In this period, the quantity of the diet was adjusted according to the average weight of the calves.

The lot feeding lasted 113 days, between the 9th of July and the 30th of October 2012. Thereafter, the animals grazed lucerne, white clover and fescue pastures in strip grazing with two or three days of occupation and herbage allowance of 5% of the steers live weight.

When any group reached an average weight of 350 kg they were finished in a lot feeding. The diet was made by 80% of a commercial ratio and 20% of moha hay with an average of 10.4% CP and 2.71 Mcal of ME per Kg of DM.

The animals were slaughtered according to the UK protocol when they reached 515 Kg of live weight, hot and chilled carcass weights were recorded. Length of the carcass, perimeter of leg and weight of the pistol cut were measured on the left half of the carcass. The dressing percentage was estimated as the relation between the weight of the hot carcass and the slaughtering weight. The relation between the hind and forequarter of the left side of carcass was calculated as the relation between the pistola cut with chilled carcass weight, and relation between the HCW with CL was estimated. During deboning of the left pistola cut, the seven most relevant cuts: tenderloin, striploin, sirloin, inside round, outside round, knuckle, rump tail were weighted and recorded. The weight of the fat, bone and trimmings were also measured. Based on this, the proportion of cutability, fat, bone and trimmings of the pistola cut was estimated.

The different variables were analyzed by mixed models considering the block effect, the WSGR (high and low), the REA EPD (high and average), the interaction between both, and the random effect of sire. For the analysis of carcass length, perimeter of leg, weight of the pistola cut and cuts from the pistola cut the HCW as a co variable.

III. RESULTS AND DISCUSSION

The descriptive information of the experiment is presented in Table 1 and the results of carcass composition are presented in Table 2.

Table 1. Descriptive statistics for some traits measured in the experiment

	Treatments *			
	High REA High WSGR	High REA Low WSGR	Avg. REA High WSGR	Avg. REA Low WSGR
Number of animals	24	26	19	17
<u>Winter Stocker I</u>				
Final weight, kg	242	203	244	204
Avg. Daily gain, g/d	556	207	570	215
<u>Grazing Stocker II</u>				
Final weight, kg	357	357	361	350
Avg. Daily gain, g/d	575	542	507	512
Days on grazing	188	267	253	305
<u>Finishing</u>				
Avg. Daily gain, g/d	1171	1273	1207	1253
Finish period, days	150	136	151	141

* Avg.= average; REA=Rib eye area EPD; WSGR= Winter stocker growth rate.

The interaction between WSGR and REA EPD was not significant, so the factors can be analyzed independently.

Table 2. Carcass composition for steers born to sires with d different Rib Eye Area EPD (REA EPD) and different Winter Stocker Growth Rate (WSGR)

	REA EPD				WSGR			
	High		Average		High		Low	
Slaugther Weight	515.6 ± 9.9		518.3 ± 10.6		520.8 ± 8.4		513.1 ± 8.6	
HCW	266.8 ± 2.5		261.9 ± 2.6		266.8 ± 1.9	a	262.0 ± 1.9	b
HCW < 220 kg (%)	0		7		0		6	
220 kg ≥ HCW < 240 kg (%)	4		19		11		19	
240 kg ≥ HCW < 260 kg (%)	29		11		37		38	
260 kg ≥ HCW < 280 kg (%)	29		44		16		13	
HCW ≥ 280 kg (%)	38		19		37		25	
Dressing (%)	51.6 ± 5.0		50.6 ± 5.2		51.6 ± 3.9	a	50.6 ± 3.9	b
Dentition	2.2 ± 0.1		2.2 ± 0.1		2.0 ± 0.1	a	2.5 ± 0.1	b
Carcass length (CL, cm)	156.4 ± 1.1	a	151.0 ± 1.1	b	156.7 ± 0.9	a	150.7 ± 0.9	b
Perimeter of leg (cm)	109.4 ± 0.3	a	106.7 ± 0.4	b	108.7 ± 0.3	a	107.4 ± 0.4	b
HCW/CL	1.69 ± 0.01	a	1.75 ± 0.01	b	1.69 ± 0.01	a	1.76 ± 0.01	b
Pistola cut (kg)	55.0 ± 0.2	a	54.1 ± 0.3	b	54.9 ± 0.3		54.3 ± 0.3	
Hind quarter/Left side of chilled carcass weight	42.7 ± 0.2	a	41.8 ± 0.3	b	42.6 ± 0.2		42.0 ± 0.2	

The interaction between REA and WSGR was not significant (P>0.05). With each factor, rows followed by different letters are significantly different (P<0.05).

Calf managed under high WSGR achieved higher HCW and meat yield. The animals with low WSGR reached slaughter at older age, they were observed to have more definite teeth than the high WSGR and a higher proportion of lighter HCW. Similar results were obtained by Hermson et al. (2004)[4] and Neel et al. (2007)[5] who demonstrated that high growth rates during winter resulted in higher HCW.

High WSGR determined carcass of higher length and higher leg perimeters and less HCW/CL relation, not observing HCW with less than 220 kg.

Steers born to bulls with higher REA presented higher carcass length, perimeter of leg, weight of pistola cut at equal HCW and best relation of hind quarter/left side of chilled carcass weight. This is in accordance with the results of Lamb et al. (1990)[6] who obtained high correlations between REA and HCW.

The results of the composition of the pistola cut are presented in Figure 1. For the composition of the pistola cut, the interactions were significant.

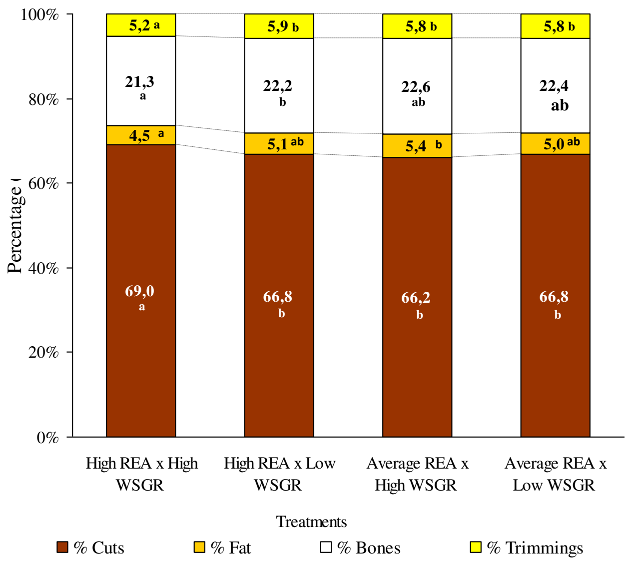

Fig. 1. Cutability, fat, bone and trimmings percentage of pistola cut for the treatments according to the UK protocol.

Animals with high REA and high WSGR had more percentage of cuts in the pistola cut, less trimming and less fat and bone in relation to the other treatments. Steers born to bulls with high REA and reared with low WSGR did not achieve the same performance as when they were with high growth rate during stoker. In the same way, the animals with average REA had less proportion of cuts when they were stocked compared to high WSGR.

Within the conformation of the pistola cut (Table 3) there was no interaction between the treatments, so response to REA EPD and WSGR are independent and additive. Steers born to high REA EPD presented higher total weight of cuts and higher weight of the rump and loin, mainly. The last is explained by higher weights of the striploin and the sirloin. Animals with high WSGR also had higher weight of the rump and loin explained by the same components.

Table 3. Pistola cut weight composition for steers born to Bulls with different Rib Eye Area EPD (REA EPD) and different Winter Stocker Growth Rate (WSGR)

Cuts (Kg)	REA EPD		WSGR	
	High	Average	High	Low
Total cuts weight*	37.4 ± 0.3 a	36.3 ± 0.3 b	37.2 ± 0.3	36.6 ± 0.3
Rump & Loin	12.420 ± 0.082 a	11.299 ± 0.103 b	12.291 ± 0.090 a	11.429 ± 0.095 b
Tenderloin	2.123 ± 0.036	2.041 ± 0.039	2.102 ± 0.029	2.062 ± 0.030
Striploin	4.987 ± 0.054 a	4.489 ± 0.067 b	4.912 ± 0.059 a	4.564 ± 0.063 b
Striploin < 4.5kg (%)	8	35	37	88
Striploin ≥ 4.5kg (%)	92	65	63	12
Sirloin	5.307 ± 0.047 a	4.754 ± 0.590 b	5.272 ± 0.051 a	4.789 ± 0.055 b
Inside Round	7.873 ± 0.071	7.731 ± 0.089	7.828 ± 0.078	7.776 ± 0.840
Outside Round	6.845 ± 0.091	6.996 ± 0.114	6.758 ± 0.099 a	7.083 ± 0.107 b
Knuckle	4.962 ± 0.047	5.103 ± 0.058	5.016 ± 0.050	5.049 ± 0.054
Rump tail	1.325 ± 0.022	1.293 ± 0.027	1.314 ± 0.024	1.303 ± 0.026

The interaction between REA and WSGR was not significant (P>0.05). With each factor, lines followed by different letters are significantly different (P<0.05). * The cuts weight includes the sum of tenderloin, striploin, sirloin, inside and outside round, knuckle, rump tail, hell muscle and shank.

IV. CONCLUSION

The results obtained in the first year of evaluation indicates that the utilization of sires with higher REA EPD and stocking with better growth rate in the first winter of life, affect positively the yield and quality of the carcass.

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EFFECT OF GENDER IN HOLSTEIN ANIMALS ON GROWTH, CARCASS AND MEAT QUALITY TRAITS

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Abstract — Thirty Holstein calves were assigned to the following treatments groups: T1=bulls (n=10); T2=cryptorchids (n=10) and T3=steers (n=10). All animals had an initial liveweight (LW) of 150 ± 21 kg fed with the same diet based on an oversown pasture grazed at 5% of LW and at 2.5% LW + supplementation at 1% LW using entire corn grain (winter). Information of carcass yield and meat quality was recorded. Daily live weight gain presented differences amongst treatments, being T1=T2>T3 (P<0.01). Higher values of hot carcass weights and carcass yield were observed (P<0.01) in T1 and T2 compared with T3. There was a significant effect (P<0.01) of the animal gender in main cuts (striploin, tenderloin, sirloin and outside flat) weights, being higher (P<0.01) for T1 and T2 compared withT3, and also in most of each cuts weights measured. The results on meat quality traits show that marbling values and fat colour where higher for T3 (P>0.01). For muscle colour, no differences were found among treatments, but a trend of lower values was observed (P<0.05) for T1 (less birghtness, red level and yellowing). These results suggest that in Holstein beef production systems, gender could play an important role to improve productivity and carcass traits.

Keywords—**Holstein beef, gender, carcass, meat quality.**

I. INTRODUCTION

Global demand for food is expected to expand more than twice by 2050. The main reasons for this include further growth in world population and an increase in income in emergent economies, which will result in an increasing demand for the consumptions of livestock-based food(1). In this scenario, meat production from non traditional breeds can play an important role in supplying animal protein. In Uruguay, Holstein meat production is gaining importance when exports associated to the NAFTA market increased. This new productive alternative has contributed to the intensification of the Uruguayan tratidional fatteing systems (2). In this country, meat derived from dairy cattle is obtained mainly from cows and steers. According to previous studies carried out in other countries, Holstein bulls grew between 10 to20% faster than steers and generate better carcass traits (3). However, little information this area of beef production has been generated in Uruguay, in particular comparing the performance, carcass traits and meat quality attributed to the effect of gender in Holstein breed. . The main objective of this study was to evaluate animal performance, carcass traits and meat quality attributes associated with gender effect in fatteing systems using Holstein breed.

II. MATERIAL AND METHODS

Thirty Holstein males were assigned to each of the following treatments: T1=bulls (n=10), T2=cryptorchids (n=10) and T3=steers (n=10). All male categories (150 ± 21 kg) were fed with the same diet. An extensive oversown pasture (Lotus subbiflorum cv El Rincón) was grazed at 5% of LW (spring, autumn and summer) and at 2.5% LW + supplementation at 1% LW using entire corn grain (winter). In three Holstein male categories (bulls, cryptorchids and steers), the following information was recorded: a) animal performance (daily LW gain-DLWG), carcass traits (Hot carcass weight-HCW; Carcass Yield–CY; sirloin, striploin and tenderloin cuts yield–R&LY; ratio of the sum of main cuts of Pistola cut-C:F; pistola weight–P; striploin weight–SL; sirloin weight–R; tenderloin weight-TL; outside flat weight-O; sum of these cut weights-C and b) meat quality attributes (pH, fat colour-FC and meat colour-MC, marbling-MARB). The muscle pH was measured using a hand-held pH meter (Orion A 230) with a probe type electrode (BC 200, Hanna Instruments), standardized against two pH buffers (4 and 7). Muscle and fat colour measurements were made using a Minolta Colorimeter (model C-10). They were recorded in triplicate from the approximate geometric center of the exposed *Longissimus dorsi* muscle, determinig values for L*, a* and b* parameters, according to the CIE system. The animal data was analyzed as repeated measurements, through the MIXED procedure of SAS and the results of carcass quality were analyzed by the GLM SAS procedure (4). LS means and differences among treatments were estimated (P<0.01).

III. RESULTS AND DISCUSSION

Initial live weight (ILW), final live weight (FLW) and daily LW gains (DLWG) of different Holstein categories are shown in Table 1. Animals in T1 and T2 had higher (P<0.01) DLWG than those in T3. These results are in accordance with numerous studies, which consistently showed that bulls grew 10-20% faster than steers (3).

Table 1. Daily LW gains for different categories

	Treatment		
	T1	**T2**	**T3**
ILW (kg)	154	160	155
FLW (kg)	518a	541a	487b
DLWG (kg/an/day)	0.72a	0.76a	0.66b

Note: IBW=Initial LW; FLW=Final Liveweight. ab – Means within the same row with uncommon uperscripts differ (P<0.01)

Carcass traits and yield for different Holstein male categories are shown in Table 2. Animals in T3 had lower (P<0.01) HCW than those in T1 and T2. FLW ranging between 510 and 540 kg allowed HCW of 270 kg. The carcass yield (CY) was 2% higher (P<0.01) in T1 than in T2. Similar differences were found by (5) when comparing CY of Holstein bulls and steers in a feedlot regime, where CY values were higher (57.9 and 559%) for bulls and steers, respectively. No treatment effect was found (P>0.01) in R&LY, but yields in forequarter cuts was lower in T3 (67.5%) than in T1 and T2 (69.7% and 70.4% respectively (data not showed). Furthermore, significant differences in C:F ratio were observed, being lower (P<0.01) in T3 than T1 and T2. Pistola Cut weight was higher (P<0.01) in T1 and T2 when compared with T3. As it was expected, differences in weights of main cuts as SL, R and O were observed as well in total sum of the cuts (C), which showed higher values (P<0.01) for T1 and T2 compared with T3.

Table 2. Carcass traits and yield cutability

	Treatment		
	T1	**T2**	**T3**
HCW (kg)	265.9a	278.3a	244.1b
CY (%)	51.9a	51.4ab	50.0b
R&LY (%)	0.72a	0.76a	0.66b
C:F (%)	23.1a	22.5a	21.2b
P (kg)	61.5a	62.9a	55.1b
SL (kg)	3.5a	3.6a	2.6b
R (kg)	2.8a	2.8a	2.3b
TL (kg)	2.2	2.1	1.9
O (kg)	5.6a	5.7a	4.9b
C (kg)	14.2a	14.2a	11.7b

Note: ab – Means within the same row with uncommon uperscripts differ (P<0.01)

Results related to meat quality traits associated with gender effect are shown in Table 3. The MARB score was different between treatments, being higher for T3 animals. These animals in T3 presented low levels of marbling, being between traces and practically devoid according to the scale of USDA Qualtiy Grade . pH values did not present any differences amongst treatments (P>0.01), and also meat colour was similar. When all three parameters of muscle colour (L*, a* and b*) were considered, no significant differences were observed. In spite of this, a better colouring trend (P>0.05) was evidenced in T2 and T3 compared to T1, showing higher values for L*, contributing to brightness and more desirable red colours. Differences by treatments in fat colour were detected, where animals in T3 had fat with more brightness (L*) and slightly more yellow (b*) than the others.

Table 3. Meat quality traits

	Treatment		
	T1	T2	T3
MARB	200b	200b	230a
pH	5.9	5.8	5.8
L* fat	60.9ab	60.0b	63.7a
a* fat	11.8a	11.6ab	9.5b
b* fat	8.8b	8.9b	11.7a
L* muscle	38.9	39.7	39.8
a* muscle	17.9	19.1	19.2
b* muscle	12.4	13.2	13.2

Note: ab – Means within the same row with uncommon uperscripts differ (P<0.01)

IV. CONCLUSIONS

The results of the present study suggest that the inclusion of bulls or cryptorchid animals in Holstein finnshing systems on grazing conditions could improve animal performance and carcass traits in Uruguay. On those systems, further research is needed associated with the achievement or not of the carcass fatness levels required by different markets as well as to study and aplly better management practices to control aggressive behavoiur of bulls in these intensive systems.

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